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Final

Remedial Design/Remedial Action Work Plan For Groundwater at Installation Restoration Program Sites 1 and 2

FORMER MARINE CORPS AIR STATION EL TORO, CALIFORNIA

January 2014

Prepared for:
Base Realignment and Closure
Program Management Office West
San Diego, California

Prepared under:
Naval Facilities Engineering Command
Contract Number N62473-11-D-2231
Contract Task Order 0002
DCN: AEJV-2231-0002-0005

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ACRONYMS AND ABBREVIATIONS

§	section
®	registered trademark
™	trademark
µg/L	micrograms per liter
1,1,2-TCA	1,1,2-trichloroethane
1,2-DCA	1,2-dichloroethane
1,2-DCE	1,2-dichloroethene
1,2,3-TCP	1,2,3-trichloropropane
cis-1,2-DCE	cis-1,2-dichloroethene
AECOM	AECOM Technical Services, Inc.
AEJV	AECOM-Envirocon Joint Venture
amsl	above mean sea level
API	American Petroleum Institute
ARAR	applicable or relevant and appropriate requirement
ARIC	area requiring institutional control
BCT	BRAC Cleanup Team
BEC	BRAC Environmental Coordinator
bgs	below ground surface
BMP	best management practices
BNI	Bechtel National, Inc.
BRAC	Base Realignment and Closure
CAGN	coastal California gnatcatcher
Cal. Civ. Code	California Civil Code
Cal. Code Regs.	California Code of Regulations
Cal/EPA	California Environmental Protection Agency
$CaCO_3$	calcium carbonate
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
C.F.R.	Code of Federal Regulations
ch.	chapter
CHMM	Certified Hazardous Materials Manager
CIH	Certified Industrial Hygienist
$Cl + O_2$	chloride + oxygen
ClO_2^-	chlorite
ClO_3^-	chlorate
ClO_4^-	perchlorate
cm/s	centimeters per second
CO	Carve-Out
COC	chemical of concern
COPC	chemical of potential concern
CQA	construction quality assurance
CQC	construction quality control
CSM	conceptual site model
CSO	Caretaker Site Office
CSP	Certified Safety Professional
CSS	coastal sage scrub
CWA	Clean Water Act
div.	division
DO	dissolved oxygen
DON	Department of the Navy

DQO	data quality objective
DTSC	Department of Toxic Substances Control
Earth Tech	Earth Tech, Inc.
EC	electrical conductivity
ECS	Enviro Compliance Solutions, Inc.
EDS-ER	Electron Donor Solution – Extended Release
e.g.	for example (exempli gratia)
EHC	Redox Compound
EOD	explosive ordnance disposal
EOS	Emulsified Oil Substrate
ESS	explosive safety submission
ESTCP	Environmental Security Technology Certification Program
etc.	and so forth (et cetera)
EVO	emulsified vegetable oil
Exec. Order No.	executive order number
FAA	Federal Aviation Administration
FBI	Federal Bureau of Investigation
$feet^2$/day	square feet per day
FFA	Federal Facility Agreement
FOSL	Finding of Suitability for Lease
FS	feasibility study
FS smoke	sulfur-trioxide chlorosulfonic acid
gpd	gallon per day
gpm	gallon per minute
HFCS	high-fructose corn syrup
HI	Hazard Index
HSA	hollow stem auger
IC	institutional control
ID	identification
i.e.	that is (id est)
IRP	Installation Restoration Program
ISB	In situ bioremediation
ITRC	Interstate Technology and Regulatory Council
LIFOC	Lease in Furtherance of Conveyance
LRA	Local Reuse Authority
LTM	long-term monitoring
LUC	land use control
Mar	March
MBTA	Migratory Bird Treaty Act
MCAS	Marine Corps Air Station
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
mg/L	milligrams per liter
MNA	monitored natural attenuation
MPPEH	material potentially presenting an explosive hazard
MSDS	material safety data sheet
msl	mean sea level
mV	millivolt
NAVFAC SW	Naval Facilities Engineering Command Southwest
Navy	Department of the Navy
NAWQC	National Ambient Water Quality Control

NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ND	not detected
NEESA	Naval Energy and Environmental Support Activity
Nov	November
NPDES	National Pollutant Discharge Elimination System
NWP	Nationwide Permit
OB/OD	open burn/ open detonation
OPS	operating properly and successfully
ORP	oxidation-reduction potential
O&M	operation and maintenance
PAL	preliminary action level
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
pH	negative log of the hydrogen ion concentration
PM	Project Manager
PMO	Project Management Office
POC	point of compliance
ppm	parts per million
PRB	permeable reactive barrier
PRG	preliminary remediation goal
psi	pounds per square inch
pt.	part
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RA	Remedial Action
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
Res.	Resolution
RG	remediation goal
RI	Remedial Investigation
ROD	Record of Decision
ROI	radius of influence
ROW	right-of-way
RPM	Remedial Project Manager
RWQCB	Regional Water Quality Control Board
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SCAQMD	South Coast Air Quality Management District
SDWA	Safe Drinking Water Act
SOP	Standard Operating Procedure
SSHSP	Site-Specific Health and Safety Plan
SWPPP	Storm Water Pollution Prevention Plan
SWRCB	State Water Resources Control Board
T-BACT	best available control technology for toxics
TBBH	total depth of borehole
TCE	trichloroethene
TCLP	toxicity characteristic leaching procedure

TCP	trichloro propane
TD	total depth
TDS	total dissolved solids
tit.	title
TO	Task Order
TOC	total organic carbon or top of casing
Trevet	Trevet Environmental Consultants
USACE	United States Army Corps of Engineers
USCS	Unified Soil Classification System
USDA	United States Department of Agriculture
USDW	underground source of drinking water
U.S.	United States
U.S.C.	United States Code
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
UXO	unexploded ordnance
VOC	volatile organic compound
WP	Work Plan
WQO	water quality objective

1. INTRODUCTION

This document presents design and implementation procedures for groundwater remedial actions (RAs) at Installation Restoration Program (IRP) Site 1 (former Explosive Ordnance Disposal [EOD] Training Range) and IRP Site 2 (Magazine Road Landfill) at former Marine Corps Air Station (MCAS) El Toro, located in Orange County, California. The principal components of this document include the following:

- *Work Plan (WP) Main Text:* The main body of this document presents engineering design and construction/implementation procedures, personnel responsibilities, and project schedule. The main text also includes an interim long-term monitoring (LTM) Plan for groundwater monitoring conducted as part of the RAs.
- *Sampling and Analysis Plan (SAP) (Attachment A):* The SAP delineates technical objectives, data acquisition and assessment procedures, and QA and QC requirements for sampling and analyses conducted as a part of the RAs.
- *Land Use Control (LUC) Remedial Design (RD) (Attachment B):* The LUC RD presents description, implementation, maintenance, and enforcement procedures for institutional controls (ICs) that are components of groundwater RAs for both IRP Sites 1 and 2.
- *Construction Quality Assurance (CQA)/ Construction Quality Control (CQC) Plan (Attachment C):* The CQA/CQC Plan presents the quality control (QC) and quality assurance (QA) procedures to be followed during the RAs.

The RAs for groundwater associated with IRP Sites 1 and 2 are consistent with the final remedies for both sites documented in the Groundwater Record of Decision (ROD) (DON 2012). These RAs will be conducted pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

This document was prepared for the Base Realignment and Closure (BRAC), Program Management Office West and the Naval Facilities Engineering Command Southwest (NAVFAC SW) under Task Order (TO) 0002 of the Performance Based Environmental Multiple Award Contracts, contract number N62473-11-D-2231.

1.1 ORGANIZATION OF THE WORK PLAN

This WP has been organized into the following sections:

- *Section 1: Introduction* – Presents the general purpose and outline of the WP.
- *Section 2: Site Background* – Presents history and summary of previous environmental investigations for IRP Sites 1 and 2.
- *Section 3: Conceptual Site Model* – Presents a summary of geology/hydrogeology, groundwater geochemistry, nature and extent of chemicals of concern (COCs), current and proposed future land/resource uses, and a summary of human-health risks for IRP Sites 1 and 2.
- *Section 4: Summary of Treatability Studies* – Presents a summary of previous treatability studies conducted at IRP Sites 1 and 2.
- *Section 5: Regulatory Framework and Remedial Action Objectives* – Presents a summary of applicable or relevant and appropriate requirements (ARARs) and remedial action objectives (RAOs) Groundwater ROD for IRP Sites 1 and 2.

- *Section 6: Selected Remedy Design – IRP Site 1* – Presents detailed design of the selected groundwater remedy for IRP Site 1.
- *Section 7: Selected Remedy Design – IRP Site 2* – Presents detailed design of the selected groundwater remedy for IRP Site 2.
- *Section 8: Remedial Action Implementation* – Presents detailed project organization and key personnel responsibilities and detailed construction/implementation procedures.
- *Section 9: References* – Provides a listing of reference materials used in this Work Plan.

Appendices

- *Appendix A: Input Parameters and Output Sheets — ESTCP Substrate Estimating Tool*
- *Appendix B: Standard Operating Procedures*
- *Appendix C: CERCLA Documentation Process and RCRA Facility Closure Comparison*
- *Appendix D: Material Safety Data Sheets*

Attachments

- *Attachment A: Sampling and Analysis Plan*
- *Attachment B: Land Use Control Remedial Design*
- *Attachment C: Construction Quality Assurance / Construction Quality Control Plan*

2. SITE BACKGROUND

2.1 SITE LOCATION

Former MCAS El Toro is situated in south central Orange County, California, approximately 8 miles southeast of Santa Ana and 12 miles northeast of Laguna Beach (Figure 2-1) and comprises approximately 4,740 acres. Former MCAS El Toro provided materials and support for Marine Corps aviation activities until the Station was closed in July 1999 under the BRAC Act.

IRP Site 1 (the former EOD Training Range) is located in the northeast portion of former MCAS El Toro in the foothills of the Santa Ana Mountains (Figure 2-1). IRP Site 2 (Magazine Road Landfill) is located on the eastern portion of former MCAS El Toro, south of IRP Site 1 (Figure 2-1).

2.2 FORMER MCAS EL TORO DESCRIPTION

MCAS El Toro was closed in July 1999, as a part of the BRAC Act. Most of the Station property has been transferred or leased by the Department of the Navy (DON) to a private owner. The DON currently owns 74 acres of the former Base that are associated with IRP Site 1 (Figure 2-2). IRP Site 2 is on property that has been transferred to the Department of Justice, Federal Bureau of Investigation (FBI).

Historically, land use around former MCAS El Toro has been largely agricultural. However, land to the south, southeast, and southwest has been developed over the past 10 years to 15 years for commercial, light-industrial, and residential uses. Currently, expanding commercial areas adjoin the Station and additional residential areas are located to the northwest and west. Adjacent land to the northeast and northwest is used for agriculture.

2.3 SITE DESCRIPTION

2.3.1 IRP Site 1

IRP Site 1 is situated within a tributary canyon of Borrego Canyon Wash at elevations ranging from approximately 610 feet to 760 feet above mean sea level (msl) (Figure 2-3). IRP Site 1 includes the Northern EOD Training Range (16.9 acres), the Southern EOD Training Range (16.6 acres), and a Buffer Zone (37 acres), among other features, for a total of approximately 74 acres (BNI 1995).

EOD training was conducted at IRP Site 1 from 1952 until closure of former MCAS El Toro on 2 July 1999. The majority of recent military EOD training took place at the Northern EOD Training Range. The Southern EOD Training Range was used for EOD training by the Orange County Sheriff's Department and various Federal agencies (BNI 1995). Several demolition pits, and a range building, are present at IRP Site 1. Military ordnance used at the Site included hand grenades, land mines, cluster bombs, smoke bombs, and rocket propelled munitions. Civilian commercial-grade explosives, such as dynamite, and plastic and gelatinous explosives have also been used at IRP Site 1. Trenches and pits were periodically excavated and munitions were detonated. The trenches and pits were then filled with soil and then subsequently reexcavated to conduct additional munitions detonation activities.

Limited historical information suggests that rocket motors or Jet-Assisted Take-Off units were handled at IRP Site 1. In 1982, approximately 2,000 gallons of sulfur trioxide chlorosulfonic acid (FS smoke) were reportedly burned in trenches located in the northern portion of the Site. An estimated 300,000 gallons of petroleum fuels were burned from 1952 through 1993. In addition, there are unconfirmed reports that low-level radioactive material was handled at the site (NEESA 1986). The potential presence of radionuclides at the Site was investigated and based on the

investigation findings, the site received unrestricted release from the California Department of Public Health in September 2007. The FBI used IRP Site 1 for training purposes (FBI 2000). The FBI's activities at IRP Site 1 included bomb technician training, post-blast investigation training, and emergency response operations. These activities involved the use of explosive devices and products.

2.3.2 IRP Site 2

IRP Site 2 was used as a landfill, shown as Areas A and B on Figure 2-4, from the late 1950s until about 1980, although some unauthorized disposal may have occurred on an intermittent basis at Areas C1, C2, and D2. During the 1970s, all solid waste from MCAS El Toro and some waste from MCAS Tustin were disposed in this landfill. Previous reports estimate 800,000 cubic yards to 1,000,000 cubic yards of waste were placed in the landfill during its operation (Strata 1991). The suspected types of waste include construction debris, municipal waste, batteries, waste oils, hydraulic fluids, paint residues, transformers, and waste solvents (BNI 1996). A soil layer of varying thickness was placed over the landfill waste.

The RA for soil at IRP Site 2 was completed in February 2008. This RA included consolidation of wastes from Areas C1/C2, and D2, and construction of an evapotranspiration cap (AECOM 2009). The operation and maintenance (O&M) of this evapotranspiration cap is currently in progress.

2.4 PREVIOUS INVESTIGATIONS

Various environmental investigations have been conducted at IRP Sites 1 and 2 as a part of the CERCLA process to characterize the physical attributes including the geology and hydrogeology, the nature and extent of contamination, potential risks to human-health and the environment, and the feasibility of potential remedial technologies. The environmental media investigated at IRP Sites 1 and 2 included soil, surface water, groundwater, and/or air. The following subsections present a summary of the investigations performed for groundwater at IRP Sites 1 and 2. The Federal Facilities Agreement (FFA) signatories reviewed and concurred with the primary documents associated with these Sites.

2.4.1 IRP Site 1

Table 2-1 presents brief summaries of key groundwater investigations conducted at IRP Site 1. Since treatability studies directly influence the RD for IRP Site 1 groundwater remedy, a more detailed summary of these studies is presented in Section 4.

2.4.2 IRP Site 2

Table 2-2 presents brief summaries of key groundwater investigations conducted at IRP Site 2. Since treatability studies directly influence the RD for IRP Site 2 groundwater remedy, a more detailed summary of these studies is presented in Section 4.

3. CONCEPTUAL SITE MODEL

The conceptual site model (CSM) is an engineering management tool that summarizes physical characteristics of the site, the nature and distribution of chemicals of concern (COCs), fate and transport of COCs, potential receptors/exposure pathways, and potential risks to human health. The CSMs for IRP Sites 1 and 2 are discussed in the following subsections.

3.1 GEOLOGY AND HYDROGEOLOGY

The selected remedy for IRP Site 1 groundwater will include in situ bioremediation (ISB) within the IRP Site 1 boundary, in the area between IRP Sites 1 and 2, and near the former MCAS El Toro Boundary (i.e., at IRP Site 2) (see Section 6 for the selected remedy summary). For IRP Site 2, the selected remedy will include implementation of monitored natural attenuation (MNA). Based on this, the summary of geology/hydrogeology is focused toward the following target remediation areas:

1. Area within the IRP Site 1 boundary
2. Area between IRP Sites 1 and 2 (hereinafter also referred to as Intermediate Area)
3. IRP Site 2 Area

The summaries presented below are primarily based on the following reports: Final Phase II Remedial Investigation (RI) Report (IRP Site 1) (Earth Tech 2006a); Final Groundwater Feasibility Study Report (IRP Sites 1 and 2) (AECOM 2011); Aquifer Characterization and Bench-Scale Treatability Testing Report (IRP Site 1) (ECS 2006); and Aquifer Test Technical Memorandum (IRP Site 2) (Earth Tech 2006b).

3.1.1 Area Within IRP Site 1 Boundary

3.1.1.1 GEOLOGY AND GROUNDWATER LEVELS

The geology in the vicinity of IRP Site 1 is predominantly poorly consolidated massive marine sandstone (bedrock) of the Oso Member of the Capistrano Formation beneath alluvial sediments (Earth Tech 2006a). The overlying alluvium consists of fine- to medium-grained sand, silty sand, and clayey sand derived from the bedrock, and varies in thickness from 0 feet (bedrock exposed at the surface) to 40 feet. The upper layer of bedrock is weathered and is generally more porous and permeable than the underlying competent (moderately indurated sandstone) bedrock.

Figure 3-1 presents the site layout and historical perchlorate assessment locations, including monitoring wells and hydropunch locations at and downgradient of IRP Site 1. Within the IRP Site 1 boundary and in an area north of hydropunch location 01-HPA8, under seasonally low rainfall/dry conditions, groundwater is primarily present in the bedrock. Groundwater levels rise into overlying alluvium in the central portion of the site in response to rainfall events. Figure 3-2 presents a groundwater equipotential map at and downgradient of IRP Site 1 for a comprehensive gauging event conducted in January 2013 (representative of low rainfall conditions). Water level measurements at and downgradient of IRP Site 1 indicate that groundwater levels rise in response to rainfall events. Based on the comprehensive round of water level measurements conducted in March 2005, groundwater levels rose approximately 10 feet on average in response to the second highest rainfall amounts recorded in the Los Angeles history.

The most recent groundwater gauging events at IRP Site 1 representative of wet and dry conditions were conducted in March 2011(Trevet 2011) and January 2013, respectively. The groundwater equipotential map based on these gauging events is presented on Figure 3-3. Based on this map, water levels within the central portion of IRP Site 1 (also referred to as the perchlorate Source Area)

reflect a south-southwest flow direction with a gradient averaging 0.05 foot per foot near the central portion of IRP Site 1.

3.1.1.2 Hydraulic Conductivity and Pumping Rates

Based on the pump tests conducted in 2005 and 2006 (ECS 2006), two primary hydraulic conductivity zones (Zone 1 and Zone 2) were identified near the central portion of IRP Site 1 (see Figure 3-3). The hydraulic conductivities for Zones 1 and 2 were estimated at $3x10^{-4}$ centimeters per second (cm/s) and $1x10^{-5}$ cm/s, respectively. Secondary porosity within Zone 1 was estimated to be 0.4 percent based on the pump tests. Secondary porosity and higher hydraulic conductivities in Zone 1 are likely the result of chemical weathering caused by fluctuating groundwater levels near the central portion of IRP Site 1 in response to variations in precipitation and groundwater recharge (ECS 2006).

Based on the aquifer tests, the long-term yields for wells completed in bedrock are expected to range from up to 1 gallon per minute (gpm) near the center of Zone 1 to 0.2-gpm or less near the northwest and southwest perimeters of Zone 1. The bedrock in Zone 2 does not yield sufficient quantities of water to operate an extraction well (ECS 2006).

For Zone 1, using the hydraulic conductivity of $3x10^{-4}$ cm/s, effective porosity of 0.27 (literature-based value for sandstone), and groundwater gradient of 0.05-foot per foot, the groundwater seepage velocity is estimated to be 57.5 feet per year. For Zone 2, using the hydraulic conductivity of $1x10^{-5}$ cm/s, effective porosity of 0.27 (literature-based value for sandstone), and groundwater gradient of 0.06-foot per foot, the groundwater seepage velocity is estimated to be approximately 2.3 feet per year.

3.1.1.3 Buried Channel and Groundwater Flow

A review of borehole logs from monitoring wells indicates that the cross-section profile of the alluvium and the saturated weathered bedrock within the IRP Site 1 boundary approximates a “V”, indicating a buried channel. This buried channel is relatively narrow within the boundary of IRP Site 1 (see Figure 3-5). However, the size and extent of the channel increases south of or downgradient of IRP Site 1 (i.e., in the area between IRP Sites 1 and 2 [see Section 3.1.1.2]). The buried channel appears to strongly influence the flow of groundwater and perchlorate transport from the central portion of IRP Site 1. It is suspected that during times of high groundwater recharge, the groundwater and perchlorate plume spread laterally upgradient of the narrow buried channel. As groundwater recharge diminishes, the water table declines and the plume contracts as perchlorate-laden groundwater predominantly discharges through the buried channel (ECS 2006).

3.1.2 Area Between IRP Sites 1 and 2

Downgradient of IRP Site 1, saturated alluvium overlies the feldspathic sandstone bedrock. The Phase II RI involved the drilling of 29 continuously cored borings (shown as Hydropunch® locations on Figure 3-1) south of IRP Site 1 boundary. These borings showed that a classic V-cut buried channel also exists south of IRP Site 1 (see cross-section D-D’ on Figure 3-5). The saturated alluvial thickness along the axis of the buried channel south of IRP Site 1 is about 40 feet to 50 feet. During the Hydropunch® investigations (Earth Tech 2006a), coarse, heaving, unconsolidated sands were commonly encountered while trying to core the alluvium in the buried channel depths. This suggests clean saturated sands and gravels with relatively high groundwater flow velocities are present at this depth.

Figure 3-2 presents a groundwater equipotential map in the area between IRP Sites 1 and 2 based on the data collected during January 2013 (representative of low rainfall conditions). The groundwater

levels reflect a south-southwest flow direction in the saturated alluvium and bedrock in the direction of IRP Site 2 with a gradient averaging 0.01-foot per foot. A summary of recent water level data collected between IRP Sites 1 and 2 in November 2010, March 2011, and January 2013 is presented in Table 3-1.

3.1.3 IRP Site 2 Area

The geology in the vicinity of IRP Site 2 consists of alluvial deposits overlying sandstone from the Topanga and Vaqueros Formations. The alluvial deposits consist primarily of fine- to medium-grained sands with silt, and silty sands. Sandstone from both formations exhibits various degrees of calcium cementation and weathering by depth and location. The upper portion of the bedrock is weathered, thus complicating the identification/location of the bedrock-alluvium contact.

Figure 3-7 presents the IRP Site 2 plan, and locations of monitoring wells and hydropunch locations at and downgradient of IRP Site 2. Based on the water level gauging conducted in March 2011 (seasonally high rainfall conditions) and January 2013 (seasonally low rainfall conditions), groundwater levels generally reflect a southern trending flow gradient averaging 0.05 feet per foot (Figure 3-7). A review of historical reports for former MCAS El Toro suggests that the groundwater gradient direction changes toward the northwest downgradient of the former MCAS El Toro Boundary. DTSC has expressed concerns in the past regarding uncertainties in groundwater gradient direction, and fate and transport of COCs south of former MCAS El Toro Boundary. As part of preparation of this Work Plan, the influence of the postulated fault south of former MCAS El Toro Boundary and depositional environment on the groundwater gradient was reviewed, and a conclusion was reached that the hydraulic gradient has the greatest influence on the flow direction. With the installation of four Alton Parkway replacement wells (02_NEW02A, and 02_NEW07A, 02_NEW26A, and 02_NEW27A), a review of groundwater elevations documented in the Well Installation Report (Trevet 2012) was performed. This review noted that the well screen intervals intercepted alluvial deposits and the general direction of groundwater gradient based on the April 2012 and January 2013 water level measurements is towards the west-northwest (see Figure 3-7).

The hydrogeologic cross-sections for IRP Site 2 area are presented on Figures 3-8 and 3-9. Groundwater occurs in the porous alluvial sediments and in bedrock sandstones and siltstones, and ranges from being unconfined to confined. Due to the interlayered heterogeneous nature of the bedrock, water bearing units within the bedrock range from being laterally and vertically isolated to partially isolated. The hydraulic properties of alluvium and bedrock water bearing zones were estimated during the pump tests conducted in 2002 and 2003 (Earth Tech 2006b). The results of these pump tests indicate that the alluvial water bearing zone (near former location of wells 02NEW02) is unconfined with relatively high transmissivity (4,400 square feet per day). The bedrock water bearing zones range from confined to unconfined with relatively low transmissivity (3 square feet per day to 240 square feet per day). The long-term pumping rates from the area near the former MCAS El Toro Boundary in the vicinity of wells 02DGMW60, 02PZ06A/B, and 02NEW13 ranged from 0.24-gpm to 0.4-gpm.

Based on the bedrock hydraulic conductivity 8.5×10^{-5} cm/s (estimated based on pump tests), effective porosity of 0.12 (literature-based value for siltstone), and groundwater gradient of 0.05-foot per foot, the groundwater seepage velocity is estimated to be approximately 36.6 feet per year.

Depths to groundwater vary seasonally and generally range from 40 feet to 70 feet below ground surface (bgs). Previous investigations using the wells south and southwest of IRP Site 2 have shown that, as the groundwater flows from IRP Site 2, the flow direction changes abruptly toward the northwest as the depth to groundwater increases to approximately 130 feet bgs.

Surface water infiltration testing has not been conducted at IRP Sites 1 and 2. Based on poorly graded and silty sands overlying the bedrock at IRP Sites 1 and 2, the infiltration rates are expected to be on the order of 0.1 to 0.8 inches per hour (USDA 2008).

3.2 GROUNDWATER GEOCHEMISTRY

Groundwater samples have been collected and analyzed for various geochemical parameters including dissolved oxygen (DO), oxidation-reduction potential (ORP), nitrate, sulfate, negative log of the hydrogen ion concentration (pH), and alkalinity as part of routine groundwater monitoring at former MCAS El Toro (Trevet 2011). Table 3-2 summarizes these data for April 2010, November 2010, and March 2011 monitoring rounds for the wells outside the zone of influence of 2009-2010 ISB Pilot Study (see Section 4 for details). A summary of geochemical data presented in Table 3-2 is shown in Table 3-3 for three target remediation areas: area within the IRP Site 1 Boundary, Intermediate Area, and the IRP Site 2 area.

Although the DO data shows relatively high variability (see Table 3-2), the average DO values indicate anoxic to aerobic conditions in groundwater within the three target remediation areas. Within the IRP Site 1 boundary and Intermediate Area, the DO values for several wells are higher for the March 2011 sampling round compared to April and November 2010 sampling rounds, potentially reflecting influence of recharge due to rain events. The maximum, minimum, and average nitrate and sulfate concentrations for the three target remediation areas are presented in Table 3-3. The sulfate concentrations in the IRP Site 2 area are much higher than the area within the IRP Site 1 Boundary, and the Intermediate Area.

3.3 NATURE AND EXTENT OF CHEMICALS OF CONCERN

3.3.1 IRP Site 1

The COC for IRP Site 1 groundwater is perchlorate. Figure 3-1 shows the estimated extent of perchlorate in groundwater at and downgradient of IRP Site 1. For each well/sampling location, the latest available perchlorate concentration data reported in the following reports and datasets are used (sampling dates ranging from 2004 to January 2013):

- Final Spring 2011 Data Summary Report, Installation Restoration Program Sites 1 and 2, Former Marine Corps Air Station El Toro Irvine, California (Trevet 2011)
- Final Technical Memorandum, In Situ Bioremediation Pilot Study, Installation Restoration Program Site 1, Explosive Ordnance Disposal Training Range Former Marine Corps Air Station El Toro, California (AECOM and ECS 2011) (Note: Pre-pilot study data is reported on Figure 3-1 for wells that were influenced by injected substrate during the pilot study)
- Pre-design sampling in support of the RD/RA.

Perchlorate has been reported in groundwater in the central portion of IRP Site 1 in the Northern EOD Training Range at concentrations exceeding the drinking water equivalent level (DWEL, a USEPA health advisory) of 24.5 micrograms per liter (µg/L) (USEPA 2006) and the California Maximum Contaminant Level (MCL) of 6 µg/L by more than one order of magnitude (see Figure 3-1). An analysis of historical operations and soil sampling results indicates that this area (hereinafter interchangeably referred to as the perchlorate Source Area or central Source Area) is likely the source of perchlorate for areas located south of IRP Site 1, including the Intermediate Area. At IRP Site 2, perchlorate in groundwater at concentrations exceeding the California MCL of 6 µg/L extends south to approximately the former Station Boundary. Perchlorate was reported in three off-Station wells below its California MCL of 6 µg/L. Based on the data collected during IRP

Site 2 investigations and during the IRP Site 1 RI, it was concluded that perchlorate in groundwater at IRP Site 2 was related to the release of perchlorate at IRP Site 1.

3.3.2 IRP Site 2

The COCs for IRP Site 2 groundwater include: trichloroethene (TCE); tetrachloroethene (PCE); cis-1,2-dichloroethene (cis-1,2-DCE); 1,1,2-trichloroethane (1,1,2-TCA); and 1,2-dichloroethane (1,2-DCA). The estimated extents of these COCs are presented on Figures 3-10 and 3-11. TCE exceeded its Federal MCL for drinking water of 5 µg/L in several monitoring wells at IRP Site 2 and is the most widely distributed COC. Based on the spatial distribution of TCE, the source of TCE appears to have originated from point sources in the unauthorized disposal Area C2, downgradient of the former operational landfill areas. Perchlorate originating from IRP Site 1 is present at IRP Site 2 at concentrations exceeding the California MCL.

3.4 CURRENT AND PROPOSED FUTURE LAND AND RESOURCE USES

3.4.1 Land Use

Former MCAS El Toro was closed on 2 July 1999. From 1994 to 2002, the County of Orange, the designated Local Reuse Authority (LRA), proposed a commercial aviation reuse for former MCAS El Toro. This proposal was submitted as a BRAC Reuse Plan. In March 2002, County voters overturned those planning efforts with the passage of Measure W, a referendum that changed the Orange County General Plan for former MCAS El Toro to a non-aviation use and recreational theme, with limited development intensities. After the March 2002 vote, the LRA decided that it would not prepare another BRAC Reuse Plan for the property. Consequently, the Navy decided not to dispose of the property with any particular reuse or redevelopment plan and that reuse would ultimately be determined by local zoning applicable at the time of sale.

In November 2003, the city of Irvine annexed the former Station property. The city of Irvine has not prepared a BRAC Reuse Plan. However, a conceptual Reuse Plan entitled “Orange County Great Park” was prepared and approved by the City of Irvine; calling for mixed uses of residential, commercial, and recreational open space.

In July 2005, the Navy completed the process of conveying the former Station through public sale to a private developer. Although the sale resulted in a majority of the property being transferred by deed, areas that required further environmental investigation and/or response actions were retained by the Navy. These areas, known as carve-outs (COs), were leased to the developer in accordance with the Finding of Suitability to Lease (FOSL) under a Lease in Furtherance of Conveyance (LIFOC). Upon meeting the environmentally suitable for transfer requirements, the COs are deeded to the buyer.

Prior to the public sale, approximately 975 acres were excluded from being determined as surplus property and were instead retained by the government. As such, an approximately 900-acre area south of IRP Site 1, including IRP Site 2, was conveyed to another Federal agency, the Federal Aviation Administration (FAA), which has since conveyed the property to another Federal agency, the FBI (Figure 2-2). The remaining acreage, which encompasses IRP Site 1, has been retained by the Navy. The Navy intends to transfer IRP Site 1 with the anticipated future use as "like-use" or an EOD Training Range.

3.4.2 Groundwater Use

Former MCAS El Toro is located within the Irvine Management Zone (formally known as the Irvine Groundwater Forebay), which has been designated by the California Regional Water Quality Control Board (RWQCB) as a public water supply source. The aquifer located directly beneath former

MCAS El Toro is not currently used for municipal water supply; however, groundwater near the former Station is used for agricultural purposes.

3.5 SUMMARY OF SITE RISKS

Human-health risk assessments for both sites were performed as part of RIs (Earth Tech 2006a and BNI 1996) to evaluate potential impacts to human-health from the chemicals of potential concern (COPCs) in groundwater at IRP Sites 1 and 2. Detailed risk assessment methodologies and results are presented in the RI Reports for IRP Sites 1 and 2. Brief summaries of these risk assessments are presented in the following sections.

3.5.1 IRP Site 1 Groundwater

Potential cancer risk from exposure (ingestion, skin contact, and inhalation while showering) to impacted groundwater associated with IRP Site 1 was estimated to be $1x10^{-3}$, which exceeds the action level (10^{-4}) typically associated with remediation requirements. The two chemicals contributing a majority of the cancer risk were TCE and arsenic. Although TCE was reported in some IRP Site 1 monitoring wells during January 2002, it has not been reported in any monitoring well at the site since January 2002. The estimated cancer risk attributable to TCE is therefore not considered to represent actual site conditions. In addition, the maximum reported concentration of arsenic in groundwater did not exceed its MCL of 10 mg/L and was within the range of background concentrations observed at former MCAS El Toro. Therefore, no response action is required for metals.

The Hazard Index (HI) associated with potential exposure to groundwater (ingestion, skin contact, and inhalation while showering) was estimated to be 10. Perchlorate was identified as a primary risk contributor to the noncancer risk and was selected as the COC for groundwater.

The cancer risk due to potential vapor intrusion into indoor air as a result of volatilization of volatile organic compounds (VOCs) from IRP Site 1 groundwater was also evaluated and estimated to be within the risk management range of 10^{-4} to 10^{-6}. The noncancer HI due to potential vapor intrusion into indoor air as a result of volatilization of VOCs from IRP Site 1 groundwater was estimated to be less than 1. Based on these risk estimates and site-specific considerations, it was concluded that VOCs in IRP Site 1 groundwater do not pose unacceptable risks to human-health via an indoor air inhalation exposure pathway.

3.5.2 IRP Site 2

The potential cancer risk to a resident downgradient of IRP Site 2 due to exposure (ingestion, skin contact, and inhalation while showering) to impacted groundwater was estimated to be $3x10^{-4}$. The majority of this risk (99 percent) was attributable to arsenic in groundwater. The HIs for children and adults due to potential exposure to groundwater downgradient of IRP Site 2 were estimated to be 6.6 and 2.8, respectively. The primary contributors to the HIs were arsenic, fluoride, manganese, and nickel.

The metal concentrations such as arsenic, manganese, and nickel are consistent with ambient levels and are not attributable to past Navy activities. Therefore, no response action is required for metals in groundwater. Potential cancer risk and noncancer HI due to potential vapor intrusion into indoor air as a result of volatilization of VOCs in groundwater was estimated to be within the risk management range of 10^{-4} to 10^{-6} and less than 1, respectively. Based on these risk estimates and site-specific considerations, it was concluded that VOCs in IRP Site 2 groundwater do not pose unacceptable risks to human-health via an indoor air inhalation exposure pathway. However, groundwater monitoring data indicate that concentrations of several VOCs exceeded their respective

regulatory thresholds (Federal and/or State MCLs) relatively consistently, and therefore were selected as COCs for IRP Site 2 groundwater.

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4. SUMMARY OF TREATABILITY STUDIES

4.1 PERCHLORATE MICROCOSM STUDY – IRP SITE 1

Microcosm treatability studies were performed using perchlorate-impacted soil and groundwater from IRP Site 1 to determine if perchlorate could serve as an electron acceptor for naturally occurring anaerobic bacteria in groundwater beneath IRP Site 1. The details of the microcosm studies are presented in the aquifer characterization and treatability studies (ECS 2006) performed subsequent to the Phase II RI.

The results of the microcosm treatability studies indicated that:

- Perchlorate degradation appears to be rapid and complete, suggesting favorable conditions for perchlorate degradation provided that ORP could be successfully reduced below ambient levels and sufficient anaerobic bacteria are available.

- The addition of high concentrations of electron donor carbon sources was not required to achieve complete utilization of the perchlorate in two weeks as both the simulated MNA and the negative control microcosms achieved the same extent of perchlorate degradation utilizing low concentrations of organics present in the soil and groundwater.

- Populations of anaerobic heterotrophic bacteria varied over a range of three orders of magnitude, with lactate and molasses proving to be the most effective carbon source for boosting bacterial densities.

- Pilot testing is essential to determine the effectiveness of the laboratory results in the field.

4.2 VOC MICROCOSM STUDY – IRP SITE 2

IRP Site 2 groundwater conditions and contaminant distribution were evaluated and bench-scale microcosm laboratory experiments were performed to measure the rate and extent of biodegradation of VOCs and perchlorate in groundwater under anaerobic conditions. The details of the evaluation and microcosm study are presented in the Contaminant Distribution in Groundwater & Microcosm Study Findings (ECS 2005).

Field parameter readings, such as dissolved oxygen (DO), ORP, electrical conductivity (EC) and pH, were collected to evaluate groundwater conditions. Groundwater samples were analyzed for VOCs, ferrous iron, perchlorate, nitrate/nitrite, total alkalinity and major ions, total Kjeldahl nitrogen, total dissolved solids, total suspended solids, pH, chemical oxygen demand and methane, ethane and ethene. A conceptual hydrogeologic model was developed based on all data collected from previous investigations.

Two microcosm studies were performed:

- Study One: Assessed potential biodegradation for four separate groundwater samples collected from wells 02PZ04, 02PZ12, 02NEW16, and 02NEW17/18 by adding equal amounts of a low molecular weight carbon food source composed of sodium lactate, molasses, or CytoSol.

- Study Two: Assessed potential biodegradation of a composite sample prepared by combining groundwater samples from wells 02PZ04, 02PZ12, 02NEW16 and 02NEW17/18 in one composite sample and adding separate low-molecular weight carbon food source composed of sodium lactate, molasses, or CytoSol.

Based on the experiment results, limited anaerobic biodegradation of PCE (45 percent to 60 percent) and TCE (15 percent to 25 percent) could potentially occur in groundwater beneath IRP Site 2 provided that ORP levels were artificially reduced below ambient levels. Generation or further decay of PCE-TCE daughter products such as 1,1-DCE, cis-DCE, trans-DCE and vinyl chloride could not be assessed from microcosm experimental data because the reported concentrations of these compounds were masked by interference effects from acetone, which was probably derived from methanol added as a carrier for spiking of PCE and TCE. Although limited degradation of TCE was observed during the microcosm studies, subsequent pilot study results indicated that TCE dechlorinating bacteria can be stimulated to reduce TCE concentrations in groundwater to less than its MCL of 5 μg/L (AECOM and ECS 2011) (see Section 4.3 for details).

Perchlorate degradation appeared to be rapid and complete in Studies One and Two, suggesting that conditions would be very favorable for perchlorate degradation provided that ORP potentials could be successfully reduced below ambient levels.

Conclusions with regard to natural attenuation of VOCs were:

- Reductive dechlorination is not an active process at IRP Site 2;
- Dilution, advection, and dispersion are the primary reduction mechanism; and
- Limited degradation of PCE and TCE will occur provided that the reducing conditions are artificially induced.

4.3 IN SITU BIOREMEDIATION PILOT STUDY – IRP SITES 1 AND 2

Overview of Methodology

A Pilot Study (AECOM and ECS 2011) was conducted to evaluate the effectiveness of ISB of perchlorate-impacted groundwater within the following two areas:

- Perchlorate Source Area in the central portion of IRP Site 1 in saturated sandstone bedrock (Figure 3-3), and
- Downgradient of IRP Site 1 near the former Station Boundary in the alluvium, and saturated sandstone/siltstone bedrock, where perchlorate commingles with TCE from IRP Site 2 (Figure 3-10).

The Pilot Study evaluated the injection of Emulsified Oil Substrate (EOS®) through injection wells to stimulate biodegradation of perchlorate and TCE in groundwater. EOS primarily consists of food-grade soybean oil emulsion with additives such as lactate and vitamin B12. Approximately 1,600 gallons of 5 percent EOS solution was injected into one injection well across the screen length of 5 feet at the Source Area. Near the Station Boundary, approximately 1,600 gallons of 5 percent EOS solution was injected into one injection well across the screen length of 15 feet.

The Pilot Study also evaluated injection of a Redox Compound (EHC®) by hydraulic fracturing to stimulate biodegradation of perchlorate and TCE in groundwater near the Station Boundary. EHC consists of a combination of controlled-release carbon and zero valent iron (ZVI). Approximately, 10,000 pounds of EHC was injected at two fracture locations oriented perpendicular to groundwater flow.

Some of the important results of the Pilot Study most relevant to the full-scale ISB design are presented below.

General Results

- EOS and EHC were effective in creating reducing conditions in the saturated alluvium/bedrock to stimulate biodegradation of perchlorate and TCE.
- Perchlorate-degrading bacteria can be readily stimulated in the subsurface to reduce concentrations of perchlorate to less than its MCL of 6 μg/L.
- TCE dechlorinating bacteria can be stimulated to reduce TCE concentrations to less than its MCL of 5 μg/L. The data also suggested that complete reductive dechlorination of TCE to ethene/ethane is possible at IRP Site 2.
- The pH values in the Source Area injection well decreased from 8.06 to 5.56 following EOS injection. For the injection well near the Station Boundary area, the pH values decreased from 6.26 to 4.93, following EOS injection. These decreases in pH values did not seem to adversely impact the biological treatment efficiencies for perchlorate or TCE. The pH values near the injection wells started to show an increasing trend (tending toward near neutral pre-injection conditions) toward the end of the Pilot Study.

Substrate Injection Parameters

- IRP Site 1 Area: Substrate injection can be effectively performed using regular pressurized injection at low pressures (approximately 0 pounds per square inch [psi] [well-head pressure] i.e., gravity feed) and moderate flow rates (3 gpm to 5 gpm) into the weathered bedrock.
- IRP Site 2 Area: Substrate injection can be effectively performed at low pressures (8 psi to 10 psi [well-head pressure]) and moderate flow rates (3 gpm to 5 gpm) into the alluvium/weathered bedrock near the Station Boundary using regular pressurized injection.

Injection Radius of Influence – IRP Site 1 Source Area

- The radius of influence (ROI) of EOS injected into the weathered bedrock at the perchlorate Source Area was estimated to be 12 feet in the direction of groundwater flow, and 5 feet transverse to the direction of groundwater flow.

Injection Radius of Influence – IRP Site 2 Area

- The ROI of EOS injected into the alluvium/weathered bedrock near the Station Boundary was estimated to be 24 feet in the direction of groundwater flow and 5 feet transverse to the direction of groundwater flow.

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5. REGULATORY FRAMEWORK AND REMEDIAL ACTION OBJECTIVES

This section presents a summary of ARARs and RAOs documented in the Final Groundwater ROD for IRP Sites 1 and 2.

5.1 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

5.1.1 IRP Site 1

Section 121(d) of the CERCLA of 1980 (42 United States code [U.S.C.] Section [§] 9621[d]), as amended, states that RAs on CERCLA sites must attain (or the decision document must justify the waiver of) any Federal or more stringent State environmental standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate. The Selected Remedy will meet all Federal or State standards, requirements, criteria, or limitations that have been determined to be ARARs for the RA for IRP Site 1 perchlorate-impacted groundwater in the Final Groundwater ROD. These ARARs are presented in Tables 5-1 through 5-5 and documentation of Navy and regulatory agency positions on the ARAR status of a few significant regulations is provided below.

Navy and the California Department of Toxic Substances Control (DTSC's) Position Regarding Resource Conservation and Recovery Act (RCRA) Permit and Closure Requirements at IRP Site 1: The State of California (DTSC) maintains that the Navy operated an open burn/open detonation (OB/OD) facility within the IRP Site 1 investigation area. DTSC stated in the letter to the Navy (dated 19 March 2001) that the OB/OD facility received interim status authorization between 8 June 1988 and 31 December 1991. It further stated that the OB/OD facility operated without any authorization from DTSC between 1 January 1992 to July 1999, in violation of State law; therefore, RCRA closure and post-closure requirements specified in Chapter 6.5 of the California Health and Safety Code and California Code of Regulations (Cal. Code Regs.), tit. 22, § 66265.112 apply to the OB/OD unit.

The Navy used munitions at the EOD Training Range for their intended purpose, including the training of military personnel, and explosives and emergency response specialists, and such training is neither waste treatment nor disposal. Therefore, the Navy maintains that activities conducted at the former EOD Training Range were not regulated under the RCRA.

Both the Navy's and DTSC's positions have been documented in the Phase II RI WP and Phase II RI for IRP Site 1. To facilitate resolution of the differing positions, the Navy indicated that it would incorporate the substantive provisions of the State's RCRA closure and post-closure requirements into the CERCLA related documentation for IRP Site 1. This position was acknowledged by the DTSC in a letter dated 19 March 2001. In accordance with this resolution, the Groundwater FS evaluated RCRA closure and post-closure requirements identified by the State in letters dated 19 March 2001 and 21 June 2006 as potential "relevant and appropriate" ARARs. The final ARARs for the IRP Site 1 groundwater RA are presented in Tables 5-1 through 5-5. In addition, Appendix C presents a comparison of CERCLA documentation process and requirements for RCRA facility closure.

Navy's Position Regarding State Water Resources Control Board (SWRCB) Resolutions (Res.) 92-49 and 68-16: The Navy recognizes that the key substantive requirements of Cal. Code Regs. tit. 22, § 66264.94 (and the identical requirements of Cal. Code Regs tit. 23, § 2550.4 and Section III.G of SWRCB Res. 92-49) require cleanup to background levels of constituents unless such restoration proves to be technologically or economically infeasible and an alternative cleanup level of constituents will not pose a substantial present or potential hazard to human-health or the environment. In addition, the Navy recognizes that these provisions are more stringent than corresponding provisions of Title 40 of the Code of Federal Regulations (C.F.R.) § 264.94 and,

although they are Federally enforceable via the RCRA program authorization, they are also independently based on State law to the extent that they are more stringent than the Federal regulations.

The Navy has also determined that SWRCB Res. 68-16 is not a chemical-specific ARAR for determining response action goals. However, SWRCB Res. 68-16 is a potential action-specific ARAR for regulating new discharges, such as treated groundwater, into the aquifer. The Navy has determined that further migration of already-contaminated groundwater is not a discharge governed by the language in Res. 68-16. More specifically, the language of SWRCB Res. 68-16 indicates that it is prospective in intent, applying to new discharges in order to maintain existing high quality waters. It is not intended to apply to restoration of waters that are already degraded.

The Navy's position is that SWRCB Res. 92-49 and 68-16 and Cal. Code Regs. tit. 23, § 2550.4 do not constitute chemical-specific ARARs for RA because they are State requirements and are not more stringent than Federal ARAR provisions of Cal. Code Regs. tit. 22, § 66264.94. The NCP set forth in 40 C.F.R. § 300.400(g)(4) provides that only State standards more stringent than federal standards may be ARARs (see also CERCLA Section 121(d)(2)(A)(ii) [42 U.S.C. § 9621(d)(2)(A)(ii)]).

The substantive technical standard in the equivalent State requirements (i.e., Cal. Code Regs. tit. 23, division (div.) 3, chapter (ch). 15 and SWRCB Res. 92-49 and 68-16) is identical to the substantive technical standard in Cal. Code Regs. tit. 22, § 66264.94. This section of Cal. Code Regs. tit. 22 will likely be applied in a manner consistent with equivalent provisions of other regulations, including SWRCB Res. 92-49 and 68-16.

State of California's Position Regarding SWRCB Res. 92-49 and 68-16: The State does not agree with the Navy's determination that SWRCB Res. 92-49 and 68-16 and certain provisions at Cal. Code Regs. tit. 23, div. 3, ch. 15 are not ARARs for this response action. SWRCB has interpreted the term "discharges" in the California Water Code to include the movement of waste from soils to groundwater and from contaminated to uncontaminated water (SWRCB 1994). However, the State agrees that the proposed action would comply with SWRCB Res. 92-49 and 68-16, and compliance with the Cal. Code Regs. tit. 22 provisions should result in compliance with the Cal. Code Regs. tit. 23 provisions. The State does not intend to dispute the ROD, but reserves its rights if implementation of the Cal. Code Regs. tit. 22 provisions is not as stringent as State implementation of Cal. Code Regs. tit. 23 provisions. Because Cal. Code Regs. tit. 22 regulation is part of the State's authorized hazardous waste control program, it is also the State's position that Cal. Code Regs. tit. 22, § 66264.94 is a State ARAR and not a Federal ARAR (United States v. State of Colorado, 990 F.2d 1565 [1993]).

Whereas the Navy and the State of California have not agreed on whether SWRCB Res. 92-49 and 68-16 and Cal. Code Regs. tit. 23, § 2550.4 are ARARs for this response action, this RD/RA Work Plan documents each party's position on the resolutions but does not attempt to resolve the issue.

5.1.2 IRP Site 2

The Selected Remedy will meet all Federal or State standards, requirements, criteria, or limitations that have been determined to be ARARs for the RA for IRP Site 2 VOC-impacted groundwater. These ARARs are presented in Tables 5-1 through 5-5. The documentation of Navy's and the State of California's position regarding the ARAR status of SWRCB Res. 92-49 and 68-16 is provided in Section 5.1.1.

5.2 REMEDIAL ACTION OBJECTIVES

RAOs are medium-specific goals for protecting human-health and the environment. The RAOs for the remediation of IRP Site 1 perchlorate-impacted groundwater and IRP Site 2 VOC-impacted groundwater were developed during the IRP Sites 1 and 2 Groundwater FS, which screened remedial technologies, and developed and evaluated remedial alternatives. These RAOs were memorialized in the Groundwater ROD (DON 2012) and included the following:

- Minimize the potential for domestic use of groundwater with concentrations of COCs exceeding the established respective remediation goals (RGs).
- Minimize migration of groundwater with concentrations of COCs exceeding the established respective RGs beyond the former MCAS El Toro Boundary.

These RAOs are consistent with the provisions of 40 C.F.R. § 300.430 (e)(2)(i), since they identify COCs, media of concern (groundwater), potential exposure pathways (domestic use), and RGs. The NCP further specifies that RGs shall establish acceptable exposure levels that are protective of human-health and the environment, and shall be developed by considering several factors including ARARs, cancer risk/noncancer hazards, factors related to technical limitations such as detection/quantification limits, factors related to uncertainty, and other pertinent information (40 C.F.R. § 300.430 [e][2][i]). The RGs for the COCs in groundwater at IRP Sites 1 and 2 were therefore established at the concentrations that comply with chemical-specific ARARs, and are protective of human-health and the environment. COCs identified for groundwater at IRP Sites 1 and 2 and their respective RGs are presented in Table 5-6.

The chemical-specific ARARs for groundwater RA at IRP Sites 1 and 2 include Federal MCLs, Federal non-zero maximum contaminant level goals (MCLGs), and State MCLs (see Table 5-1). In order to comply with ARARs and protect human-health, the RGs for COCs for remediation of perchlorate-impacted groundwater associated with IRP Site 1 and VOC-impacted groundwater associated with IRP Site 2, were set at the values that represent the most stringent of the Federal MCL, Federal non-zero MCLGs, and State of California MCL (see Table 5-6).

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6. SELECTED REMEDY DESIGN – IRP SITE 1

6.1 SELECTED REMEDY FOR PERCHLORATE

The selected remedy to address perchlorate associated with IRP Site 1 documented in the Groundwater ROD (DON 2012) includes the following components:

- ISB at the perchlorate Source Area;
- ISB downgradient of the perchlorate Source Area between IRP Sites 1 and 2;
- ISB near the former Station Boundary; and
- Groundwater monitoring and ICs.

Implementing ISB will include injection of an electron donor or substrate into the subsurface. ISB stimulates indigenous microorganisms to grow and multiply by using injected substrate as a carbon and energy source, thereby degrading perchlorate into innocuous end products such as chloride ions and oxygen (see schematic below for the degradation pathway for perchlorate by sequential removal of chloride atoms from the anion). The Groundwater ROD also stipulates that the design configurations for the implementation of ISB at the Source Area may include a permeable reactive barrier (PRB), direct injection (in a grid pattern), or groundwater recirculation. The design configurations for the implementation of ISB between IRP Sites 1 and 2, and near the former Station Boundary may include a PRB (with or without groundwater recirculation).

$$ClO_4^- \longrightarrow ClO_3^- \longrightarrow ClO_2^- \longrightarrow Cl^- + O_2$$

Perchlorate Chlorate Chlorite Chloride + Oxygen

Schematic: Perchlorate Degradation Pathway

Groundwater monitoring will be conducted to evaluate the effectiveness of ISB in treating perchlorate. ICs, including groundwater use restrictions, will also be implemented to limit potential human exposure to perchlorate-impacted groundwater until the RG established for perchlorate is achieved. Once the RG (the State of California drinking water MCL) is achieved, the ICs will be terminated.

6.2 DESIGN BASIS

This section presents the basis of design for ISB of perchlorate-impacted groundwater at the three target remediation areas: perchlorate Source Area, Intermediate Area, and the area near the former Station Boundary. The design of an ISB system includes various components including but not limited to the following:

1. ISB design configuration (e.g., PRB or direct injection in a grid pattern).
2. Design of injection wells/locations for subsurface emplacement of substrate/electron donor. This includes spacing between injection wells/locations, and selection of the thickness and depth of injection interval/well screens.
3. Type and quantity of substrate (including injection volumes and dilution ratios) proposed for injection (i.e., substrate loading)

The following elements of the CSM developed during the RI/FS phase (Earth Tech 2006a and AECOM 2011) and the data obtained from the 2009-2010 ISB Pilot Study (AECOM and ECS 2011) serve as major inputs to the ISB design:

- Distribution of perchlorate in groundwater
- Site geology/hydrogeology
- Site geochemistry
- Treatability study results including estimated ROI

6.2.1 Distribution of Perchlorate in Groundwater

The lateral extent of perchlorate in groundwater at and downgradient of IRP Site 1 is shown on Figure 3-1 and discussed in Section 3.1.3.1. The vertical extents of perchlorate in the three target remediation areas (Source Area, Intermediate Area, and area near the former Station Boundary) are provided on the cross-sections shown on Figures 3-5 and 3-6. These lateral and vertical extents form the basis for spatial placement of substrate injection locations and injection depth interval.

6.2.2 Site Geology and Hydrogeology

A summary of geology/hydrogeology including geological cross-sections of each target remediation area is presented in Section 3.1.1. A summary of major geological/hydrogeological parameters used in the ISB design for each target remediation area is presented in Table 6-1.

6.2.3 Site Geochemistry

The geochemical parameters for each target remediation area are summarized in Section 3.1.2. The average geochemical parameters based on the data collected during April 2010, November 2010, and March 2011 monitoring rounds, summarized in Table 3-3, were used for ISB design including substrate loading.

6.2.4 Treatability Study Results

An ISB Pilot Study was conducted to evaluate the effectiveness of ISB within IRP Site 1 Source Area and near the former Station Boundary (IRP Site 2 Area where perchlorate is commingled with TCE). A summary of the results of the ISB Pilot Study most relevant to the full-scale ISB design are presented in Section 4.1.1.2.

6.3 ISB DESIGN PARAMETERS

The recommended ISB design configurations and parameters (e.g., type/quantity of substrate, injection geometry, locations, and treatment thickness) for the three target remediation areas for IRP Site 1 perchlorate impacted groundwater are presented below.

6.3.1 Overall ISB Approach/Design Configurations

The overall ISB approach for the Source Area will include the following:

- Installation of an injected PRB immediately downgradient of the Source Area
- Active ISB within the Source Area using direct injection.

As discussed in Sections 3.1.1.1, perchlorate migrates downgradient of the Source Area through a narrow buried V-channel composed of alluvium/weathered bedrock in the vicinity of wells 01-

PZ21A/B. Therefore, an injected PRB will be installed in the vicinity of Wells 01-PZ21A/B to control further downgradient migration of perchlorate and cut-off the Source Area (see Figure 6-1). The detailed design and implementation strategy for this injected PRB is presented in Section 6.4.

Groundwater modeling conducted in support of the FS (AECOM 2011) indicated that the overall timeframe required to achieve the RG for perchlorate within the Source Area is estimated to be approximately 90 years if a PRB immediately downgradient of the Source Area is used without any active ISB within the Source Area. Therefore, to reduce the perchlorate mass within the Source Area, overall remediation time-frame, and life-cycle costs for the remedy, active ISB will be conducted within the Source Area. ISB within the Source Area will include injecting and distributing the substrate within the Source Area to the extent practicable to stimulate naturally-occurring bacteria to degrade perchlorate into innocuous end products such as chloride ions and oxygen. The detailed design and implementation strategy for ISB within the Source Area are presented in Section 6.4.

The ISB in the Intermediate Area and near the former Station Boundary will be implemented using injected PRBs (see Figure 6-1). The detailed designs and implementation strategies for the Intermediate Area and Station Boundary PRBs are presented in Sections 6.5 and 6.6, respectively.

6.3.2 ISB Design Parameters

6.3.2.1 General Substrate Injection Strategy

The following subsections present general strategies for substrate injection using wells and direct push points. The detailed standard operating procedures for substrate injection are presented in Appendix B. In addition, the specific injection quantities for substrates are discussed in the detailed ISB design for each target remediation area in Sections 6.4, 6.5, and 6.6.

Injection Wells

The substrate will be gravity fed or injected into wells using pumps operated at relatively low pressures (less than 20 psi) to avoid fracturing of the formation. The injection and distribution of substrate within the subsurface will be hydraulically controlled by extracting groundwater from nearby wells during injection to enhance distribution of substrate away from the injection well (see Figure 6-2 for conceptual process flow schematic). The number of injection and extraction wells to be brought on-line simultaneously will depend on the specific ISB location and practical considerations such as ability to effectively control flow rates and pressures at individual injection/extraction locations.

Groundwater will be extracted from wells located adjacent to or near the injection wells using submersible pumps. The extracted groundwater will be used as dilution water for substrate at a central dosing unit. Since, based on the pilot studies, the injection rates are expected to be higher than groundwater extraction rates, a portion of dilution/chase water will be obtained from a nearby fire hydrant. Diluted substrate will be injected into wells through a multi-channel manifold with simultaneous groundwater extraction from nearby wells. Following injection of substrate, chase water may be injected, if required, to enhance substrate distribution and flush the wells to limit biological growth and/or plugging of injection wells screens.

Direct Push

Direct push technology (when used) will inject substrate using a “top-down” approach at each proposed injection point. This approach will include advancement of injection tooling to the first (most shallow) treatment interval (approximately 10 feet in thickness) and injection of the desired

volume of dilute substrate into the formation. The substrate injection may be followed by chase water, if required, to enhance substrate distribution. Upon completion, the injection tooling will be advanced to the next 10-foot treatment interval and dilute substrate/chase water will be injected. More than one direct push injection point may be manifolded and injected into simultaneously, to maximize efficiency.

6.3.2.2 Radius of Influence and Well Spacing

Source Area and Former Station Boundary Area

Asymmetric substrate ROIs were observed during the pilot studies conducted at the Source Area and near the former Station Boundary (see Section 4.1.1.2 for details). The observed ROIs were longer in the direction of groundwater flow compared to the cross-gradient direction. Therefore, as described in Section 6.3.2.1, a hydraulically-enhanced substrate injection strategy will be used to enhance distribution of substrate away from the injection wells particularly in the cross-gradient direction. Table 6-2 presents the design target ROIs and injection point spacings estimated based on the ISB Pilot Study results, and considering that hydraulically-enhanced substrate injection strategy will be used for the injected PRBs at the Source Area and near the former Station Boundary.

The objective of active ISB within the Source Area is to distribute substrate to the extent practicable to reduce perchlorate mass in groundwater. During the aquifer tests conducted within the IRP Site 1 Source Area, the extraction of groundwater at a well within Zone 1 (see Figure 3-3) had an influence on a monitoring well located in excess of 75 feet in the direction transverse to the groundwater flow. Therefore, substrate distribution within Zone 1 of the Source Area will be conducted using consecutive injection and extraction wells placed 40 feet to 50 feet apart transverse to groundwater flow direction. The localized areas of perchlorate impact upgradient of Zone 1 and within Zone 2 will receive injection of substrate without hydraulic enhancement into existing wells.

Intermediate Area

The ISB Pilot Study was not conducted in the Intermediate Area; therefore, no ROI data are available for this area. The design target ROI for the Intermediate Area reported in Table 6-2 is an estimated value based on the local geology in the area and ROIs observed during the 2009-2010 ISB Pilot Study at the Source Area and near the Station Boundary. The soil types constituting the target treatment interval near the proposed location of the Intermediate Area PRB consist of sands, silty sands, and sandy silts. In general, these soil types are expected to be more permeable compared to sandstone and siltstone bedrocks encountered within the Source Area and near the former Station Boundary. Therefore, the design ROI for the Intermediate Area was conservatively estimated to be equal to the ROI observed in the Source Area during the ISB Pilot Study.

Since the soil types within the target treatment zone of the Intermediate Area PRB consist of sands, silty sands, and sandy silts, direct push technology will be used to inject substrate for this PRB as explained in Section 6.3.2.1. Direct push (where feasible) is a cost-effective injection strategy and allows more flexibility in terms of substrate emplacement compared to injection wells. The ISB performance monitoring proposed for the Intermediate Area will be used to evaluate if the desired zone of influence for injected substrate is attained to create an effective PRB (see Section 6.7.3 of this Work Plan and Section 11.1 of Attachment A).

6.3.2.3 Substrate Selection

Emulsified vegetable oil (EVO) was selected as the substrate for establishing injected PRBs at the Source Area, Intermediate Area, and the former Station Boundary because of its longevity in the subsurface. The reasons for the selection of EVO are presented below:

- Once EVO is injected, replenishment is not required for 1.5 years to 3 years (ITRC 2011); therefore, the use of EVO is expected to be cost-effective since it would eliminate the need for continuous or more frequent injection of substrate into the subsurface.
- EVO has been shown to effectively stimulate biodegradation of perchlorate and TCE during the 2009-2010 Pilot Study (AECOM and ECS 2011).
- EVO offers flexibility in terms of subsurface injection into wells or direct push. In addition, EVO is amenable to hydraulically-enhanced substrate injection.

There are various formulations of EVO commercially-available in the market for groundwater remediation. Most of these EVOs (including the EVO used during the 2009-2010 Pilot Study and the EVO proposed for remedial action in this Work Plan) are vegetable oil-based products and are expected to have similar long-term performance for perchlorate bioremediation. The specific formulation of EVO proposed for this project is Electron Donor Solution - Extended Release (EDS-ER™) available from Tersus Environmental. EDS-ER is a water-soluble oil formulated with at least 92 percent natural seed oils (see Appendix B for details). EDS-ER provides food-grade carbon and is made from renewable crop-based oils. EDS-ER is provided by the vendor as water-mixable oil; therefore, it will be emulsified in the field. This will reduce the cost and environmental footprint associated with substrate transport to the site. Appendix D presents the material safety data sheets (MSDSs) for substrate and tracer dyes to be injected.

For ISB within the Source Area, high-fructose corn syrup (HFCS) was selected. HFCS is a food-grade, low-cost, soluble substrate that moves with groundwater and lasts a few months in the subsurface. Microcosm studies conducted using soil and groundwater samples collected from IRP Site 1 evaluated the effectiveness of soluble substrates similar to HFCS, including lactate and molasses for perchlorate biodegradation (see Section 4.1). These studies along with data from site-specific pilot studies and published literature, show that perchlorate biodegradation is rapid and complete using a variety of soluble substrates. Therefore, HFCS will be cost-effective to reduce the mass of perchlorate within the Source Area.

6.3.3 Substrate Loading

The quantity of substrate required for injection was calculated based on the stoichiometric demand using Environmental Security Technology Certification Program's (ESTCP) spreadsheet-based Substrate Estimating Tool (ESTCP 2010). The geochemical and hydrogeological parameters for estimating substrate demand for the ISB areas are presented in Tables 3-3 and 6-1, respectively. To account for uncertainties and as recommended in the ESTCP guidance (ESTCP 2010), the calculated quantity of substrate based on the stoichiometric demand was multiplied by the design safety factor of 3 for EVO and 2 for HFCS to estimate the design substrate loading recommended in this Work Plan.

For EVO, retention of oil droplets occurs as the emulsion migrates through the pore spaces in the subsurface. The amount of oil retention depends on the type of subsurface matrix (e.g., weathered rock vs. clays). The amount of oil retained by the aquifer material was estimated as part of this design using published values (Solutions-IES 2006) of effective retention (i.e., pounds of EVO per pound of treated sediment) for soil types observed at the proposed ISB locations. These estimates were less than the estimated quantities of EVO based on the stoichiometric demand.

Implementation of the remedial action is not anticipated to adversely impact water quality locally or down-gradient of the site in the long-term. The electron donors injected as part of ISB create reducing conditions in the subsurface. Over the short term, this change may cause formerly insoluble forms of metals to dissolve and become mobile over short distances within the aquifer

matrix. Any mobilized metals are expected to be adsorbed, precipitated, and/or immobilized immediately down-gradient of the reactive zone when oxidizing conditions are restored. Therefore, these temporary water quality impacts due to ISB are expected to be localized and for a relatively short-duration.

6.4 SOURCE AREA ISB DESIGN

As discussed in Section 6.3.1, ISB at the Source Area will include the following:

- Installation of an injected PRB immediately downgradient of the Source Area
- Active ISB within the Source Area by direct injection of substrate.

6.4.1 Source Area PRB

6.4.1.1 PRB LOCATION

The proposed PRB location immediately downgradient of the Source Area is shown on Figures 6-1 and 6-3. The rationale for the selection of this location is presented below:

- The estimated extent of perchlorate is expected to be limited horizontally (less than 30 feet transverse to the direction of groundwater flow) and vertically (less than 50 feet bgs). Therefore, a PRB can be cost-effectively installed at the selected location to control downgradient migration of perchlorate through the paleochannel.
- The ISB design parameters such as ROI and substrate injection rates were well defined by the 2009-2010 ISB Pilot Study. In addition, the existing injection well (01-IW01) and monitoring wells (01-MW-225A/B, 01-MW226) installed during the pilot study can be used as substrate injection and/or performance monitoring wells for the proposed PRB.

6.4.1.2 PRB TYPE

The Source Area PRB will include a line of injection wells transverse to the direction of groundwater flow as shown on Figure 6-3. EVO will be injected into these injection wells to create a biologically reactive zone that covers the lateral and vertical extents of perchlorate-impacted groundwater (exceeding its RG) migrating downgradient from the Source Area. The rationale for selection of EVO for ISB is presented in Section 6.3.2.3.

6.4.1.3 WELL PLACEMENT AND DESIGN

Two injection wells (01-IW03 and 01-IW04) will be installed in the vicinity of existing Injection Well 01-IW01, for subsurface injection of EVO (see Figure 6-3). The injection well spacing of 15 feet is based on the rationale presented in Section 6.3.2.2. The proposed placement of injection wells is intended to cover the estimated lateral extent of perchlorate exceeding its RG transverse to the direction of groundwater flow. This extent is defined to the northwest by existing Well 01-MW205 but is uncertain to the southeast of existing Injection Well 01-IW01. Therefore, an implementation strategy that affords flexibility with respect to placement of injection wells southeast of Well 01-IW01 has been developed and is presented in Section 8.2.1.

Table 6-3 presents the screen intervals and depths of existing and proposed injection/monitoring wells for the Source Area PRB. These screen intervals and depths are based on the estimated vertical extent of perchlorate at the proposed location of the Source Area PRB (see Figure 3-5). The well screen placements and lengths may be modified during field implementation activities based on field observations including depth of alluvium/bedrock contact and groundwater.

6.4.1.4 Substrate Loading and Injection

The mass of EVO required for establishment of the Source Area PRB was calculated based on the stoichiometric demand exerted by the native (e.g., DO, nitrate, and sulfate) and anthropogenic (perchlorate) electron acceptors. These calculations were performed using the ESTCP spreadsheet-based Substrate Estimating Tool (ESTCP 2010). The input parameters and output sheets for the Substrate Estimating Tool are presented in Appendix B.

The specific formulation of EVO proposed for establishing Source Area PRB is EDS-ER. EDS-ER provides food-grade carbon and is made from renewable crop-based oils. Based on the stoichiometric demand, the total estimated weight of EDS-ER proposed for injection is 688 pounds (see Table 6-4). As discussed in Section 6.3.2.1, the EDS-ER will be injected into the subsurface using a hydraulically-enhanced injection strategy as summarized in Table 6-5 and described below:

1. **Phase I:** The concentrated solution of EDS-ER will be diluted by mixing 1 part of EDS-ER with 5 parts of water. During mixing, sodium bromide (at target concentration of 500 mg/L) and fluorescein dye will be added to the solution. Sodium bromide and visual observation of the fluorescein dye will be used to evaluate distribution of injected EDS-ER during performance monitoring (see Section 6.7 for details). The diluted EDS-ER solution will be injected into Wells 01-IW01 and 01-MW225B followed by 10 parts of chase water per 1 part of dilute EDS-ER. During the entire duration of injection, groundwater extraction will be conducted from Wells 01-IW03 and 01-IW04, to enhance distribution of substrate cross-gradient. The extracted groundwater supplemented with hydrant water will be used as dilution water for substrate injection, and hydrant water (not amended with extracted groundwater) will be used as chase water. The specific injection volumes for EDS-ER and chase water for Phase I injection are presented in Table 6-5.
2. **Phase II:** The concentrated solution of EDS-ER will be diluted by mixing 1 part of EDS-ER with 5 parts of water. During mixing, sodium bromide (at a target concentration of 500 mg/L) and fluorescein dye will be added to the solution. The diluted EDS-ER solution will be injected into Wells 01-IW03 and 01-IW04 followed by 10 parts of chase water per 1 part of dilute EDS-ER. Groundwater extraction will be initiated from Wells 01-IW01 and 01-MW225B concurrent with the initiation of substrate injection. If significant milkiness (visual evidence of injected EDS-ER during Phase I) is observed in the extracted groundwater from either of the two extraction wells, substrate injection and groundwater extraction will be suspended for 1 to 3 days to avoid extraction of EDS-ER injected during Phase I and two allow more time for adsorption of EDS-ER to subsurface material. Substrate injection into Wells 01-IW03 and 01-IW04 and groundwater extraction from Wells 01-IW01 and 01-MW225B will be resumed after the suspension period. If the extracted groundwater is not observed to be milky, substrate injection and groundwater extraction will continue until the entire volume of EDS-ER presented in Table 6-5 is injected. Else EDS-ER will be injected into Wells 01-IW03 and 01-IW04 without concurrent groundwater extraction. The specific injection volumes for EDS-ER and chase water are presented in Table 6-5.

Following completion of substrate injection, performance monitoring will be conducted as summarized in Section 6.7. This performance monitoring will be used to evaluate the depletion of substrate over time. If the data evaluation based on the decision rules presented in Worksheet 11 of the SAP (Attachment A) indicates that substrate is no longer present in sufficient quantity to sustain biodegradation, additional rounds of substrate injection will be evaluated.

6.4.2 Source Area Direct Injection

6.4.2.1 Well Placement and Design

Active ISB within the Source Area will include injection of HFCS to enhance the biodegradation of perchlorate in groundwater. As discussed in Section 6.3.2.1, within Zone 1 (shown on Figure 3-3), the HFCS will be injected into the subsurface using a hydraulically-enhanced injection strategy. Upgradient of Zone 1 and within Zone 2, HFCS will be injected without hydraulic enhancement into existing wells.

The proposed wells for substrate emplacement within Zones 1 and 2, and upgradient of Zone 1 are listed in Table 6-6 and shown on Figure 6-4. Table 6-6 also shows the screen intervals and depths of existing and proposed wells based on the estimated vertical extent of perchlorate (see Figure 3-5). The well screen placements and lengths may be modified during field implementation activities based on field observations including depth of alluvium/bedrock contact and groundwater.

6.4.2.2 Substrate Loading and Injection

The mass of HFCS required for ISB within the Source Area was calculated separately for the following areas:

1. Zone 1 area where HFCS will be injected using a hydraulically-enhanced injection strategy
2. Localized areas upgradient of Zone 1 and within Zone 2, where HFCS will be injected without hydraulic enhancement into existing wells.

The substrate estimates are based on the stoichiometric demand exerted by the native (e.g., DO, nitrate, and sulfate) and anthropogenic (perchlorate) electron acceptors. These calculations were performed using the ESTCP spreadsheet-based Substrate Estimating Tool (ESTCP 2010). The input parameters and output sheets for the Substrate Estimating Tool are presented in Appendix B. The following subsections present details of the substrate injection strategies for the Source Area.

Zone 1

The commercially-available food-grade HFCS will be diluted by mixing 1 part of HFCS with 10 parts of water. During mixing, sodium bromide (at a target concentration of 500 mg/L) and fluorescein dye will be added to the solution to evaluate the distribution of substrate during performance monitoring (see Section 6.7 for details).

During *Phase I* of substrate injection, approximately, 1,147 gallons of dilute HFCS solution (in water) will be injected into each of the twelve Zone 1 injection wells listed in Table 6-7. During the entire duration of injection, groundwater extraction will be conducted from Zone 1 extraction wells listed in Table 6-7, to enhance distribution of substrate cross-gradient. The extracted groundwater supplemented with hydrant water will be used as dilution water for substrate. The specific injection volumes of HFCS for Phase I injection are presented in Table 6-7.

Following completion of Phase I, Phase II injection will be initiated, which will include injection of approximately 1,147 gallons of dilute HFCS solution into each of the nine wells which were used as extraction wells during Phase I injection (see Table 6-7).

Localized Areas Upgradient of Zone 1 and within Zone 2

The HFCS will be diluted by mixing 1 part of HFCS with 10 parts of water. Approximately 108 gallons of dilute HFCS solution will be injected into each of the six wells listed in Table 6-7 for

areas upgradient of Zone 1 and within Zone 2. The dilution water will be obtained from a nearby fire hydrant.

6.5 INTERMEDIATE AREA PRB DESIGN

6.5.1 PRB Location

The proposed PRB location in the Intermediate Area is shown on Figures 6-1 and 6-5. The rationale for the selection of this location is presented below:

- The groundwater treatment interval is expected to be primarily within the alluvium (see Figure 3-6). Therefore, substrate injection is likely not required in the bedrock and can be performed more cost-effectively.
- The location captures relatively high perchlorate concentrations (exceeding 100 µg/L), is easily accessible, and does not encroach on the Metropolitan Water District of Southern California water line.

6.5.2 PRB Type

The Intermediate Area PRB will include a line of injection locations/points transverse to the direction of groundwater flow as shown on Figure 6-5. EVO will be injected into each injection point using direct push technology to create a biologically reactive zone that covers the lateral and vertical extents of perchlorate-impacted groundwater (exceeding its RG) migrating downgradient. The rationale for selection of EVO for the Intermediate Area PRB is presented in Section 6.3.2.3.

6.5.3 Injection Locations Placement and Design

Ten direct push locations (01-DPT01 through 01-DPT10) and one well (01-MW231) will be used to inject EVO transverse to the direction of groundwater flow to establish the Intermediate Area PRB (see Figure 6-5). The spacing of 15 feet between injection locations is selected based on the rationale presented in Section 6.3.2.2. The proposed placement of injection points is intended to cover the estimated lateral extent of perchlorate exceeding its RG transverse to the direction of groundwater flow. This extent needs to be refined to the northwest of Well 01-PZ15 and to the southeast of Well 01-MW214. Therefore, an implementation strategy that affords flexibility with respect to placement of injection wells northwest of Well 01-PZ15 and to the southeast of well 01-MW214 has been developed and is presented in Section 8.2.1.

Table 6-8 presents the injection intervals for direct push points and screen intervals for monitoring wells for the Intermediate Area PRB. These injection/screen intervals are based on the estimated vertical extent of perchlorate at the proposed location of the Intermediate Area PRB (see Figure 3-6). The injection/well screen intervals and lengths may be modified during field implementation activities based on field observations including depth of alluvium/bedrock contact and groundwater.

6.5.3.1 SUBSTRATE LOADING AND INJECTION

The mass of EVO required for the establishment of the Intermediate Area PRB was calculated based on the stoichiometric demand exerted by the native (e.g., DO, nitrate, and sulfate) and anthropogenic (perchlorate) electron acceptors. These calculations were performed using the ESTCP spreadsheet-based Substrate Estimating Tool (ESTCP 2010). The input parameters and output sheets for the Substrate Estimating Tool are presented in Appendix B.

The specific formulation of EVO proposed for the Intermediate Area PRB establishment is EDS-ER. Based on the stoichiometric demand, the total estimated weight of EDS-ER proposed for injection is

4,080 pounds (see Table 6-4). The concentrated solution of EDS-ER will be diluted by mixing 1 part of EDS-ER with 5 parts of water. During mixing, sodium bromide (at a target concentration of 500 mg/L) and fluorescein dye will be added to the solution to evaluate distribution of substrate during performance monitoring (see Section 6.7 for details). The diluted EDS-ER solution will be injected into injection points 01-DPT01 through 01-DPT10, and Well 01-MW231.

The injection of EDS-ER into injection points 01-DPT01 through 01-DPT10 will be conducted using direct push technology. At each direct push point, injection tooling will be advanced to the first (most shallow) treatment interval (approximately 10 feet in thickness) and approximately 123 gallons of dilute substrate will be injected into the formation. This will be followed by injection of approximately 1,230 gallons of hydrant chase water. Upon completion, the injection tooling will be advanced to the next 10-foot treatment interval, and the same volumes of dilute substrate and hydrant chase water will be injected. More than one direct push injection point may be manifolded and injected into simultaneously to maximize efficiency.

The dilute EDS-ER will be gravity fed or injected into Well 01-MW231 using a pump operated at relatively low pressure. Table 6-9 presents a summary of volumes for EDS-ER and chase water for Intermediate Area PRB establishment.

Following completion of substrate injection, performance monitoring will be conducted as summarized in Section 6.7. This performance monitoring will be used to evaluate the depletion of substrate over time. If the data evaluation based on the decision rules presented in Worksheet 11 of the SAP (Attachment A) indicates that substrate is no longer present in sufficient quantity to sustain biodegradation, additional rounds of substrate injection will be evaluated.

6.6 FORMER STATION BOUNDARY PRB

6.6.1 PRB Location

The proposed PRB location near the former Station Boundary is shown on Figures 6-1 and 6-6. The rationale for the selection of this location is presented below:

- The proposed location captures the estimated extent of perchlorate exceeding its RG based on the routine groundwater monitoring results (Trevet 2011) from the last three years (April 2008 to March 2011).
- The location allows the use of the existing fracture network created in two boreholes (02-IW02 and 02-IW03, see Figure 6-6) during the 2009-2010 ISB Pilot Study for distribution of substrate for PRB establishment.
- The ISB design parameters such as substrate injection rates are well defined by the 2009-2010 ISB Pilot Study.

6.6.2 PRB Type

The Station Boundary PRB will include a line of injection wells transverse to the direction of groundwater flow as shown on Figure 6-6. EVO will be injected into these injection wells to create a biologically reactive zone that covers the lateral and vertical extents of perchlorate-impacted groundwater (exceeding its RG) migrating downgradient. The rationale for selection of EVO for ISB is presented in Section 6.3.2.3.

6.6.3 Well Placement and Design

Two injection wells (02-IW02 and 02-IW03) will be completed at the locations of two boreholes where hydraulic fracturing and injection of Redox Compound (EHC®) was conducted during the 2009-2010 ISB Pilot Study. The 2009-2010 Pilot Study confirmed through the following lines of evidence that an extensive network of fractures was created for substrate distribution in the vicinity of 02-IW02 and 02-IW03 over a length of at least 50 feet transverse to the direction of groundwater flow and throughout the vertical treatment interval:

1. The ROI of EHC was estimated to be 20 feet to 25 feet based on the total organic carbon (TOC) and geochemical data (e.g., DO, nitrate, and sulfate) collected from a network of monitoring wells in the vicinity of the fracture boreholes.
2. The TOC and volatile fatty acid (fermentation products of EHC) data collected from nested monitoring wells (02-NEW34A, B, C, D, E, &F and 02-NEW35A, B, C, D, E, &F [destroyed during the storm events in 2010]) (see Figure 2-4) indicated that hydraulic fracturing was effective in distributing substrate across the entire vertical treatment interval.
3. Mapping of subsurface fractures using tiltmeter geophysics indicated that the effective fracture radius ranged from approximately 20 feet to 30 feet.

Therefore, the injection of substrate using completed wells at 02-IW02 and 02-IW03 will allow cost-effective distribution of substrate using the existing fracture network to create an effective PRB upgradient of Wells 02NEW30 and 02PZ04.

The PRB to the east and northeast of Well 02PZ04 will be established using Injection Wells 02-IW04 through 02-IW08 (see Figure 6-6). The injection well spacing of 30 feet was selected based on the rationale presented in Section 6.3.2.2. The proposed placement of injection wells is intended to cover the estimated lateral extent of perchlorate exceeding its RG transverse to the direction of groundwater flow. This extent is defined to the west/northwest by existing Well 02NEW30 but is uncertain to the east/southeast of existing well 02PZ12. Therefore, an implementation strategy that affords flexibility with respect to placement of injection wells northeast of Well 02PZ12 and proposed Well 02-IW08 has been developed and is presented in Section 8.2.3.

Table 6-10 presents the screen intervals and depths of existing and proposed injection/monitoring wells for the Station Boundary PRB. These screen intervals and depths are based on the estimated vertical extent of perchlorate at the proposed location of the Station Boundary PRB (see Figure 3-9). The well screen placements and lengths may be modified during field implementation activities based on field observations including depth of alluvium/bedrock contact and groundwater.

6.6.4 Substrate Loading and Injection

The mass of EVO required for the establishment of the Station Boundary PRB was calculated based on the stoichiometric demand exerted by the native (e.g., DO, nitrate, and sulfate) and anthropogenic (perchlorate) electron acceptors. These calculations were performed using the ESTCP spreadsheet-based Substrate Estimating Tool (ESTCP 2010). The input parameters and output sheets for the Substrate Estimating Tool are presented in Appendix B.

The specific formulation of EVO proposed for the Station Boundary PRB establishment is EDS-ER. Based on the stoichiometric demand, the total estimated weight of EDS-ER proposed for injection is 6,292 pounds (see Table 6-4). As discussed in Section 6.3.2.1, the EDS-ER will be injected into the subsurface using hydraulically-enhanced injection strategy as summarized in Table 6-11 and described below:

1. **Phase I:** The concentrated solution of EDS-ER will be diluted by mixing 1 part of EDS-ER with 5 parts of water. During mixing, sodium bromide (at a target concentration of 500 mg/L) and fluorescein dye will be added to the solution to evaluate distribution of substrate during performance monitoring (see Section 6.7 for details). The diluted EDS-ER will be injected into Wells 02-IW02, 02-IW04, 02-IW06, and 02-IW08 followed by 10 parts of chase water per 1 part of dilute EDS-ER. During the entire duration of injection, groundwater extraction will be conducted from Wells 02-IW03, 02-IW05, and 02-IW07, to enhance distribution of substrate cross-gradient. The extracted groundwater supplemented with hydrant water will be used as dilution water for substrate injection, and hydrant water (not amended with extracted groundwater) will be used as chase water. The specific injection volumes for EDS-ER and chase water are presented in Table 6-11.
2. **Phase II:** The concentrated solution of EDS-ER will be diluted by mixing 1 part of EDS-ER with 5 parts of water. During mixing, sodium bromide (at a target concentration of 500 mg/L) and fluorescein dye will be added to the solution to evaluate distribution of substrate during performance monitoring (see Section 6.7 for details). The diluted EDS-ER will be injected into Wells 02-IW03, 02-IW05, and 02-IW07 followed by 10 parts of chase water per 1 part of dilute EDS-ER. Groundwater extraction will be initiated from Wells 02-IW02, 02-IW04, 02-IW06, and 02-IW08 concurrent with the initiation of substrate injection. If significant milkiness (visual evidence of injected EDS-ER during Phase I) is observed in extracted groundwater from one or more extraction wells, substrate injection and groundwater extraction will be suspended for 1 to 3 days to avoid extraction of EDS-ER injected during Phase I and two allow more time for adsorption of EDS-ER to subsurface material. Substrate injection (Wells 02-IW03, 02-IW05, and 02-IW07) with concurrent groundwater extraction (Wells 02-IW02, 02-IW04, 02-IW06, and 02-IW08) will be resumed after the suspension period. If significant milkiness is not observed in extracted groundwater, substrate injection and groundwater extraction will continue until the entire volume of EDS-ER presented in Table 6-11 is injected. Else EDS-ER will be injected into Wells 02-IW03, 02-IW05, and 02-IW07 without concurrent groundwater extraction. The specific injection volumes for EDS-ER and chase water are presented in Table 6-11.

Following completion of substrate injection, performance monitoring will be conducted as summarized in Section 6.7. This performance monitoring will be used to evaluate the depletion of substrate over time. If the data evaluation based on the decision rules presented in Worksheet 11 of the SAP (Attachment A) indicates that substrate is no longer present in sufficient quantity to sustain biodegradation, additional rounds of substrate injection will be evaluated.

6.7 INTERIM GROUNDWATER MONITORING PLAN

Pursuant to the ROD (DON 2012), groundwater monitoring will be conducted as a component of the remedial action for IRP Site 1 to evaluate the effectiveness of ISB in treating perchlorate. The detailed DQOs for the design and field implementation procedures for the groundwater monitoring program are presented in Attachment A. This section presents a brief summary of the monitoring objectives, monitoring well network, and sampling and analysis schedule.

6.7.1 Monitoring Objectives

The monitoring objectives for the IRP Site 1 groundwater remedy may be divided into the following two categories: short-term and long-term. Short-term objectives are geared toward demonstrating that the groundwater remedy is operating properly and successfully (OPS). The long-term objectives are formulated to evaluate if RAOs and RGs are attained. Both short-term and long-term objectives are presented below:

Short-Term Objective

- Evaluate if ISB is performing as designed and operating properly to protect human-health and the environment.

Long-Term Objectives

- Evaluate the perchlorate distribution in groundwater to confirm that the remedy is continuing to be protective of human-health and the environment.
- Evaluate if concentrations of perchlorate are reduced to less than its RG across the estimated extent of VOC-impacted groundwater.

The following types of groundwater monitoring will be conducted to achieve the above objectives:

1. Baseline groundwater sampling to characterize baseline concentrations of perchlorate and geochemical parameters prior to the start of ISB (*Baseline Monitoring*).
2. Groundwater sampling in the vicinity of ISB implementation areas to evaluate the performance of ISB to treat perchlorate (*ISB Performance Monitoring*).
3. Groundwater sampling over the entire extent of perchlorate-impacted groundwater including areas between active ISB areas to track the distribution of perchlorate following the start of ISB (*Overall Perchlorate Extent Monitoring*).

6.7.2 Baseline Monitoring

The baseline groundwater sampling will be a single-event to characterize the baseline perchlorate concentrations, and geochemical conditions prior to emplacement of bioremediation substrate. Since perchlorate-impacted groundwater is commingled with IRP Site 2 VOC-impacted groundwater near the former Station Boundary, baseline monitoring for the IRP Site 1 remedy will also include groundwater sampling and analysis for VOCs to the extent necessary to evaluate future performance of the Station Boundary PRB. The baseline groundwater sampling results will be compared with monitoring results following substrate emplacement to assess the performance of ISB. In addition, baseline data will be used to cross-check the input values for substrate demand calculations performed in this RD/RA Work Plan. The baseline sampling plan is summarized in Table 6-12.

6.7.3 ISB Performance Monitoring

When a bioremediation substrate including EVO or HFCS is injected into the subsurface, the naturally-occurring bacteria are stimulated and degrade the injected organic substrate. Biodegradation of substrate depletes the DO and other terminal electron acceptors (e.g., nitrate or sulfate), and lowers the ORP of groundwater, thereby creating conditions conducive to the anaerobic COC degradation processes. The ISB performance monitoring will be conducted to evaluate distribution of substrate, and to assess changes in geochemical conditions and perchlorate concentrations due to biodegradation reactions.

The ISB performance monitoring plans for the Source Area PRB, Source Area Treatment, Intermediate Area PRB, and Station Boundary PRB are presented in Tables 6-13, 6-14, 6-15, and 6-16, respectively. The information obtained from each proposed analyte is presented in Table 6-17.

Tables 6-13, 6-15, and 6-16 present proposed monitoring locations for each PRB along with the rationale for the selection of each monitoring location. In general, for each PRB, groundwater sampling is proposed from the following locations:

- Upgradient wells to monitor influent COC concentrations in groundwater flowing into the PRBs.
- Injection/monitoring wells within the PRBs to assess the injection zone of influence and performance data within the PRB. These wells (in conjunction with downgradient monitoring wells) will be used to provide indication of EVO consumption and the need for replenishment of substrate.
- Downgradient monitoring wells to monitor effluent COC concentrations and effectiveness of the PRB. The data from these wells will be used in conjunction with wells within the PRB to evaluate if the injection zone of influence is adequate to achieve biodegradation of perchlorate.

As discussed in detail in Section 3.1.3.2, perchlorate is commingled with VOCs (primarily TCE) near the Station Boundary. Therefore, the monitoring plan for the Station Boundary PRB will also include sampling and analysis for COCs and their biodegradation products including VC, ethene, and ethane (see Table 6-16).

The ISB monitoring plan for treatment within the Source Area is presented in Table 6-14. Monitoring locations include representative injection and extraction wells within Zone 1, and all injection wells within Zone 2 and upgradient of Zone 1 to evaluate decreases in perchlorate concentrations and changes in geochemistry.

6.7.4 Overall Perchlorate Extent Monitoring

Groundwater monitoring will be conducted over the entire extent of perchlorate-impacted groundwater including areas between active ISB areas to track the distribution of perchlorate following the start of ISB. Table 6-18 presents the plan for overall perchlorate extent monitoring. This plan is optimized based on the following:

1. Monitoring wells that satisfy all of the following criteria will be sampled once during Year 1: (1) wells have been routinely sampled at least once a year from July 2004 to March 2011, and perchlorate concentrations have been reported to be less than its RG during all monitoring rounds (2) located upgradient of the perchlorate Source Area, and (3) based on the available data on perchlorate concentrations and direction of groundwater gradient, there is no potential for perchlorate to migrate from upgradient sources at concentrations exceeding it RG. These analytical results obtained from these wells will be evaluated as follows:
   - The well for which the perchlorate concentration is less than its RG will not be sampled further during the RA.
   - The well for which the perchlorate concentration exceeds its RG will be added to the list of wells monitored semi-annually for Years 1 through 3.
2. Monitoring wells for which perchlorate concentrations have exceeded its RG at least once during the past but the latest available data (as of January 2013) show perchlorate concentrations less than its RG, will be sampled semi-annually during Year 1 and the results will be evaluated as follows:
   - The well for which perchlorate concentrations are less than its RG during both monitoring rounds and for which there is no potential for perchlorate to migrate from upgradient sources at concentrations exceeding its RG (based on the available data on perchlorate concentrations and direction of groundwater gradient) will not be sampled further during the remedial action.

- The well for which perchlorate concentrations exceed its RG at least once will be sampled semi-annually for Years 2 and 3.

3. Monitoring wells for which the latest available data (as of January 2013) show perchlorate concentrations exceeding its RG will be sampled semi-annually from Years 1 through 3 and the results will be evaluated as follows:

   - The well for which perchlorate concentrations are less than its RG during all monitoring rounds and for which there is no potential for perchlorate to migrate from upgradient sources at concentrations exceeding its RG (based on the available data on perchlorate concentrations and direction of groundwater gradient) will not be sampled further during the RA.
   - The well for which perchlorate concentrations exceed its RG at least once will be added to the list of wells monitored annually after Year 3. The current monitoring plan presented in Table 6-18 shows that all monitoring wells proposed for semi-annual sampling during Years 1 through 3 will be sampled annually after Year 3. However, the monitoring program after Year 3 will be revised/optimized appropriately based on the results of the first three years of monitoring (see Section 6.7.5).

4. The need for continued groundwater sampling and analysis from newly-installed monitoring wells 02_NEW07A, 02_NEW26A, 02_NEW27A, and 02-NEW42 will be evaluated following comprehensive review of PRB performance data and perchlorate distribution data near the Station Boundary.

6.7.5 Optimization of Monitoring Network/Schedule

The groundwater monitoring will be conducted for IRP Site 1 remedy in accordance with the monitoring plan summarized in Sections 6.7.2 through 6.7.4. After each monitoring round, data review will be conducted to evaluate progress toward attainment of short- and long-term objectives presented in Section 6.7.1, and RAOs. The data review will also be performed to optimize the locations of monitoring points and proposed analyses. The optimization plan for the overall perchlorate extent monitoring is presented in Section 6.7.4. The monitoring program in support of ISB at the Source Area, Intermediate Area, and former Station Boundary will also be optimized periodically to attain the DQOs presented in Attachment A. The recommendations for optimization will be documented in the annual reports and/or in a field change request (FCR). This annual report/FCR will present the proposed optimization/change to the monitoring program along with the rationale for the change. Some of the examples of the scenarios where optimization of monitoring network/schedule may be required for ISB systems are presented below:

- The monitoring program may be revised/optimized to troubleshoot certain conditions such as decreases in pH due to substrate biodegradation reactions to the extent that it is shown to be detrimental to perchlorate-degrading microorganisms. A buffer may need to be injected in this case to revive perchlorate-degrading bacteria and the monitoring program may need to be modified with respect to well locations and analytes such as pH and alkalinity.
- Monitoring for anions (nitrate and sulfate) and methane may be discontinued for the Source Area and Intermediate Area PRBs if data collected for at least three monitoring rounds indicate little or no change to these parameters and if other parameters such as perchlorate, TOC, DO, and ORP are deemed to be sufficient to attain the monitoring objectives and evaluate geochemical conditions.

6.8 INSTITUTIONAL CONTROLS

ICs will be implemented as part of selected remedy to limit exposure of future landowner(s) and/or user(s) to perchlorate-impacted groundwater and to maintain the integrity of the RA components such as monitoring wells. In accordance with Section 2.9.2.1 of the ROD (DON 2012), the land-use restrictions will achieve the following objectives:

- Prevent activities that present unacceptable risk to human-health due to impacted groundwater; and
- Protect site security and RA components, such as monitoring wells, fences, and signs.

The areas requiring institutional controls (ARICs) for IRP Site 1 perchlorate-impacted groundwater are shown on Figure 6-7 and consist of the following:

- A 74-acre area constituting IRP Site 1 currently owned by the Navy (also referred to as IRP Site 1 Property)
- Property downgradient of IRP Site 1 currently owned by the FBI
- Leased property consisting of portions of COs II-V-2 and/or II-F-2
- Off-Station property

A LUC RD has been prepared that presents detailed use restrictions, and legal mechanisms for implementation and inspections/monitoring plans for ICs for IRP Site 1 perchlorate-impacted groundwater. This LUC RD is presented in Attachment A of this document.

6.9 "OPERATING PROPERLY AND SUCCESSFULLY" DEMONSTRATION

An "OPS" determination will be made for the IRP Site 1 groundwater remedy signifying that the remedy is functioning properly and operating as designed. This determination will be made in accordance with the following guidance documents:

1. *Guidance for Evaluation of Federal Agency Demonstration that Remedial Actions are Operating Properly and Successfully Under Comprehensive Environmental Response, Compensation, Liability Act (CERCLA) Section 120 (h)(3)* (USEPA 1996)
2. *Close Out Procedures for National Priorities List Sites* (USEPA 2011)

USEPA interprets the term OPS to mean that the RA is functioning in such a manner that it is expected to adequately protect human-health and the environment when completed (USEPA 1996). The USEPA's 2011 Guidance states that the specific criteria for determining that the remedy is operational and functional (similar to OPS) will vary for each remedy and site. The following factors are listed in USEPA's 1996 guidance to be considered during making decisions on OPS determination:

1. *Risk to Public Health and Environment:* There should not be any current exposure to contamination that results in an unacceptable risk to public health or the environment. If the integrity of the RA depends on ICs (e.g., deed restrictions, well drilling prohibitions) these controls should be clearly identified and agreed upon.
2. *Enforceability:* This factor pertains to the USEPA's ability to ensure that the Federal agency continues operation of the remedy, or makes changes (e.g., constructs new extraction wells) to the remedy. If there are provisions in an enforceable document which require that necessary refinements to the remedial system be made in an expeditious manner after property is

transferred, the USEPA Region may not need as much assurance on remedy performance as may be necessary without such an enforcement vehicle.

3. *Technology Reliability:* This factor pertains to whether the remedial technology has been shown to successfully mitigate the COCs.
4. *Site Characterization:* This factor pertains to the quality of the site characterization, particularly for complex sites.

The OPS determination will be made for the IRP Site 1 groundwater remedy after the following:

1. Physical construction of the remedy and monitoring systems including injection and monitoring wells is completed in accordance with the approved design.

2. The shakedown period where minor modifications are made to ensure that the remedy is operating as designed, is complete. The remedy will be deemed operating as designed if monitoring data indicate that biodegradation of injected substrate has started and reducing conditions are developing in the subsurface for perchlorate biodegradation.

The OPS determination will be documented in a report that demonstrates that both of the above conditions have been met. This report will be submitted to the USEPA for concurrence/approval.

6.10 PLAN FOR VERIFYING ATTAINMENT OF RAOS/ EXIT STRATEGY

Verification monitoring will be initiated once it is demonstrated to the satisfaction of the regulatory agencies that perchlorate concentrations are reduced to levels at or below its RG. The verification monitoring will include two sampling events over a period of 1 year. The purpose of verification monitoring will be to show that perchlorate concentrations remain at or below its RG pursuant to requirements of Cal. Code Regs. tit. 22, Section 66264.100(g)(1) determined to be relevant and appropriate for the IRP Site 1 groundwater response action. If verification monitoring data show that perchlorate concentrations remain at or below its RG, then performance monitoring will be terminated and recommendation for no further action will be made for groundwater at the site.

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7. SELECTED REMEDY DESIGN – IRP SITE 2

7.1 SELECTED REMEDY DOCUMENTED IN THE GROUNDWATER ROD

The selected remedy for IRP Site 2 documented in the Groundwater ROD (DON 2012) includes the following components:

- MNA
- ICs

MNA will rely on natural attenuation processes such as dispersion, dilution, sorption, and volatilization; and monitoring for remediation of IRP Site 2 VOC-impacted groundwater. Groundwater monitoring will be conducted as a component of the remedy to evaluate the effectiveness of natural attenuation processes to reduce the concentrations of COCs and evaluate their potential migration. ICs, including groundwater use restrictions, will also be implemented to limit potential human exposure to VOC-impacted groundwater until the remediation goals (RGs) established for VOCs are achieved. Once the RGs are achieved (see Table 5-6), the ICs will be terminated.

The USEPA guidance on MNA recommends identifying a contingency remedy, which is a cleanup technology or approach that functions as a backup remedy if MNA fails to perform as anticipated. The protectiveness of the Selected Remedy will be evaluated as part of the 5-year review. If this evaluation indicates that the Selected Remedy is not protective (e.g., a documented unacceptable risk to human-health and/or the environment), the need for implementing a contingency remedy will be evaluated.

The contingency remedy documented in the ROD (DON 2012) for groundwater at IRP Site 2 is ISB which would be implemented near the Station Boundary. Results from the Pilot Study indicate that ISB implemented for treating perchlorate near the Station Boundary also creates conditions in groundwater that enhance the biodegradation of VOCs, and as a result, would complement and enhance the MNA remedy implemented for IRP Site 2. No triggers are necessary to be established for the contingency remedy at IRP Site 2, since ISB will be implemented concurrently near the Station Boundary as a component of the IRP Site 1 remedy.

7.2 DESIGN BASIS

This section presents the basis of design for the implementation of MNA for VOC-impacted groundwater at IRP Site 2, which includes installation of additional groundwater monitoring wells, and collection and analyses of groundwater samples for COCs to evaluate MNA performance.

The following elements of the CSM developed during the Phase I and Phase II RIs, and supplemental investigations following the RIs, including short- and long-term aquifer tests; an ISB pilot study; and a groundwater monitoring program for Anomaly Area 3, and IRP Sites 1 and 2 serve as major inputs to the MNA design:

- Distribution of VOCs in groundwater
- Site geology/hydrogeology
- Treatability study results

7.2.1 Distribution of VOCs in Groundwater

The estimated extents of the COCs (TCE; PCE; cis-1,2-DCE; 1,1,2-TCA; and 1,2-DCA) in groundwater at IRP Site 2 are presented on Figures 3-8 through 3-11, and discussed in Section 3.1.3.2. The extents presented on these figures were used to propose additional monitoring wells.

7.2.2 Site Geology and Hydrogeology

A summary of the site geology and hydrogeology for IRP Site 2 is presented in Section 6.2.2 under "Former Station Boundary Area".

7.2.3 Treatability Study Results

IRP Site 2 groundwater conditions and contaminant distribution were evaluated and bench-scale microcosm laboratory experiments were performed to measure the rate and extent of biodegradation of VOCs and perchlorate in groundwater under anaerobic conditions. The details of the evaluation and microcosm study are presented in Section 4.1.2.1. Some of the important conclusions with regard to natural attenuation are presented below:

- Reductive dechlorination is not an active process and does not significantly contribute to the reduction in VOC concentrations at IRP Site 2;
- Dilution, advection, and dispersion are the primary reduction mechanisms; and
- Limited degradation of PCE and TCE will occur provided that the reducing conditions are artificially induced.

7.3 MNA DESIGN

The individual elements of MNA design for COCs in IRP Site 2 groundwater per the US EPA guidance document entitled *Performance Monitoring of MNA Remedies for VOCs in Ground Water* (USEPA 2004) are presented below.

7.3.1 Objectives and Decision Points

The Selected Remedy for IRP Site 2 VOC-impacted groundwater will be designed and implemented to meet the RAOs presented in Section 5.2. The COCs and the established RG for each COC are presented in Table 5-6.

The groundwater monitoring conducted as part of IRP Site 2 selected remedy will be designed to satisfy the following objectives formulated based on the RAOs:

- Evaluate the distribution of COCs in groundwater to confirm that the remedy is continuing to be protective of human-health and the environment.
- Evaluate if concentrations of COCs are reduced to less than their respective RGs across the estimated extent of VOC-impacted groundwater.

The implementation of MNA will include installation of additional groundwater monitoring wells, and collection and analyses of groundwater samples for COCs to evaluate MNA performance. Section 7.3.2 presents detailed MNA design and Figure 7-1 shows locations of the wells proposed for groundwater monitoring. The results of groundwater monitoring will be evaluated based on the below-mentioned decision rules.

- **Decision Rule 1:** If data evaluation indicates that COC concentrations in groundwater show a stable or decreasing trend, and sampling data shows COC concentrations less than their respective RGs in downgradient Wells 02_NEW27A and 02_NEW07A, then groundwater monitoring will continue as planned until the RGs are attained.
- **Decision Rule 2:** If data evaluation indicates that COC concentrations in one or more monitoring wells located within the plume show a significant increasing trend (inconsistent with the CSM and not originally anticipated during remedy selection), then the protectiveness of the remedy will be evaluated.
- **Decision Rule 3:** If data evaluation indicates that COC concentrations in one or more monitoring wells located within or at the leading edge of the plume show a significant increasing trend (inconsistent with the CSM and not originally anticipated during remedy selection), then the protectiveness of the remedy will be evaluated.
- **Decision Rule 4:** If it is demonstrated to the satisfaction of the regulatory agencies that COC concentrations are reduced to levels at or below their respective RGs, verification monitoring will be initiated.
- **Decision Rule 5:** If verification monitoring data show that COC concentrations remain at or below their respective RGs, then performance monitoring will be terminated and recommendation for no further action will be made for groundwater at the site.

7.3.2 Monitoring Network and Schedule

7.3.2.1 Additional Monitoring Well Installation

The currently existing monitoring well network at IRP Site 2 will be supplemented with additional wells to satisfy the groundwater monitoring objectives presented in Section 7.3.1. The currently estimated extents of COCs shown on Figures 3-10 and 3-11 were used to propose additional monitoring wells. The most widespread COC in IRP Site 2 groundwater is TCE. The remaining COCs have been reported at concentrations exceeding their respective RGs at isolated locations within the boundaries of the estimated lateral extent of TCE exceeding its RG. Therefore, TCE extent forms the primary basis for proposed well locations.

Three new wells (02-NEW28A, and 02-NEW41, and 02-NEW42) are proposed to be installed for groundwater monitoring at IRP Site 2. The locations of existing and proposed monitoring wells are presented on Figure 7-1, and their screen intervals and depths are presented in Table 7-1. Well 02-NEW28A is proposed in the vicinity of the former location of Well 02NEW28 destroyed during the Winter 2010 storm events. TCE was reported at concentrations exceeding its MCL relatively consistently in samples collected from well 02-NEW28 from May 2005 to November 2010. Well 02-NEW41 is proposed to refine TCE extent exceeding its RG upgradient of Well 02NEW29. Well 02-NEW42 is proposed to refine TCE concentrations and extent to the west/northwest of the plume.

The screen intervals of all proposed wells presented in Table 7-1 have been selected to intercept the VOC-impacted groundwater near the water table based on the geology and VOC extents depicted on Figures 3-8 and 3-9.

7.3.2.2 Groundwater Monitoring Schedule

MNA will include groundwater monitoring to evaluate potential migration and decreases in concentrations of COCs due to natural attenuation processes such as dilution, dispersion, sorption, and volatilization. The detailed DQOs for the design and field implementation procedures for the groundwater monitoring program are presented in Attachment A. This section presents a brief summary of the monitoring well network, and sampling and analysis schedule.

Table 7-2 presents the proposed groundwater monitoring plan for IRP Site 2 MNA. The analytical parameters include VOCs, and field parameters (DO, ORP, and pH). TCE has been reported at higher concentrations compared to other COCs and also the most widespread in groundwater. Therefore, monitoring wells have been selected based primarily on the extent of TCE in groundwater. The rationale for selection of each monitoring well is presented in Table 7-2. The wells near the TCE plume boundary will be used to define the plume boundaries and will be sampled annually. The wells within the TCE plume will be sampled semi-annually for the first three years to evaluate decrease in COC concentrations due to natural attenuation mechanisms.

In addition, well 02NEW08A has been added to the groundwater sampling program for IRP Site 2 MNA. PCE was reported at concentrations exceeding its RG of 5 μg/L in samples collected from well 02NEW08A during routine groundwater monitoring conducted from December 1995 to September 2001 and then from March 2005 through November 2006 (Trevet 2011). However, PCE has been reported at concentrations less than its RG in samples collected from well 02NEW08A as part of routine groundwater monitoring from December 2007 through March 2011 (Trevet 2011). The reported concentration of PCE in a sample collected from well 02NEW08A during March 2011 sampling round was 4.9 μg/L (see Figure 3-10). Therefore, annual monitoring is proposed for well 01-NEW08A to verify that PCE concentrations remain less than its RG.

It should be noted that the current monitoring plan presented in Table 7-2 shows that all monitoring wells proposed for annual or semi-annual sampling during Years 1 through 3 will be sampled annually after Year 3. However, the monitoring program after Year 3 will be revised/optimized appropriately based on the results of the first three years of monitoring (see Section 7.3.3).

7.3.3 Optimization of Monitoring Network/Schedule

The groundwater monitoring will be conducted for IRP Site 2 remedy in accordance with the monitoring plan summarized in Section 7.3.2. After each monitoring round, data review will be conducted to evaluate progress toward attainment of objectives presented in Section 7.3.1, and RAOs. The data review will also be performed to optimize the locations of monitoring points and proposed analyses. The recommendations for optimization will be documented in the annual reports and/or in a FCR. This annual report/FCR will present the proposed optimization/change to the monitoring program along with the rationale for the change. Some of the examples of the scenarios where optimization of monitoring network/schedule may be required are presented below:

- One or more wells included in the monitoring program to define the extent of TCE plume may be deleted from routine groundwater monitoring program if the following conditions are satisfied: (1) at least three years of performance monitoring data show COC concentrations below their respective RGs (2) data evaluation indicates that plume is stable and there is no potential for COCs to migrate to the subject wells at concentrations exceeding their respective RGs in future.
- One or more wells included in the monitoring program within the current extent of TCE plume may be de deleted from routine groundwater monitoring program if the following conditions are satisfied: (1) at least three years of performance monitoring data show COC concentrations below their respective RGs, (2) there is no potential for COCs to migrate to the subject wells at concentrations exceeding their respective RGs in future.

7.3.4 Evaluation of Remedy Performance

The data collected based on the proposed monitoring schedule presented in Section 7.3.2 will be used to periodically evaluate the performance of natural attenuation mechanisms to achieve RAOs/RGs. The evaluations will include:

1. Evaluation of spatial and temporal trends in concentrations of COCs (see Section 7.3.3.1 for details).
2. Comparison of COC concentrations in downgradient Wells 02_NEW07A and 02_NEW27A outside the currently-defined TCE plume boundary with established RGs (see Section 7.3.3.1 for details).
3. Groundwater modeling to evaluate plume migration and progress toward attainment of RAOs/RGs.

The proposed methods along with frequencies for the above evaluations are presented in the subsections below (see Section 7.3.3.1 for details).

7.3.4.1 Proposed Data Analysis Methods

The groundwater monitoring data collected as part of MNA implementation will be analyzed to evaluate if overall monitoring objectives based on the decision rules presented in Section 7.3.1 are achieved. The data evaluation methods and frequencies are presented in Table 7-3. The proposed data analysis methods will take into account potential influence of the injected PRB near the Station Boundary on COC concentrations (see Section 6-6).

7.3.4.2 Groundwater Modeling

A groundwater flow and transport model was developed to evaluate the groundwater remedial alternatives for the IRP Site 2 VOC-impacted groundwater during the FS stage (AECOM 2011). The United States Geological Survey's Modular Three-dimensional Finite-difference Groundwater Flow Model (MODFLOW), a finite-difference computer code was used in the groundwater flow simulations. A mass transport model (Zhang 1990) was used for all transport simulations for TCE. The groundwater flow model was calibrated based on water levels observed between 1994 and 2004 at the site; and the transport processes were calibrated to the 2005 TCE plume configuration.

The existing groundwater model for IRP Site 2 will be used to evaluate the progress of the remedy to attain RG for TCE (primary COC) in conjunction with data analysis methods presented in Section 7.3.3.1. Prior to evaluation, the existing model will be updated with additional data (groundwater elevation data and TCE concentrations) collected after 2004 and as part of the first four years to five years of remedy implementation. In addition, the following hydraulic, transport, and chemical parameters will be adjusted in the model to reflect the current TCE plume configuration: hydraulic conductivity, storage, porosity, dispersion, and biodegradation rate. Model simulations will be performed prior to the first 5-year review to evaluate remedy performance.

7.4 Institutional Controls

ICs will be implemented as part of selected remedy to limit exposure of future landowner(s) and/or user(s) to VOC-impacted groundwater and to maintain the integrity of the RA components such as monitoring wells. In accordance with Section 2.9.2.1 of the ROD (DON 2012), the land-use restrictions will achieve the following objectives:

- Prevent activities that present unacceptable risk to human-health due to impacted groundwater; and
- Protect site security and RA components, such as monitoring wells, fences, and signs.

The ARICs for IRP Site 2 VOC-impacted groundwater are shown on Figure 6-7 and consist of the following:

- Property currently owned by FBI
- Leased property consisting of COs II-V-2 and II-F-2
- Off-Station property

A LUC RD has been prepared that presents detailed use restrictions, and legal mechanisms for implementation and inspections/monitoring plans for ICs for IRP Site 2 VOC-impacted groundwater. This LUC RD is presented in Attachment A of this document.

7.5 "OPERATING PROPERLY AND SUCCESSFULLY" DEMONSTRATION

An OPS determination will be made for IRP Site 2 groundwater remedy signifying that the remedy is functioning properly and operating as designed. The guidance documents and factors to be considered in making OPS determinations are listed in Section 6.9.

The OPS determination will be made for IRP Site 2 groundwater remedy after the monitoring system including monitoring wells have been installed and at least one round of groundwater monitoring has been conducted pursuant to the approved RD document. The OPS determination will be documented in a report, which will be submitted to the USEPA for concurrence/approval.

7.6 PLAN FOR VERIFYING ATTAINMENT OF RAOS/ EXIT STRATEGY

Verification monitoring will be initiated once it is demonstrated to the satisfaction of the regulatory agencies that COC concentrations are reduced to levels at or below their respective RGs. The verification monitoring will include two monitoring events over a period of 1 year. The purpose of verification monitoring will be to show that the COC concentrations remain at or below their respective RGs pursuant to requirements of Cal. Code Regs. tit. 22, Section 66264.100(g)(1) determined to be relevant and appropriate for the IRP Site 2 groundwater response action. If verification monitoring data show that COC concentrations remain at or below their respective RGs in all monitoring wells, then performance monitoring will be terminated and recommendation for no further action will be made for groundwater at the site.

8. REMEDIAL ACTION IMPLEMENTATION

8.1 PROJECT ORGANIZATION AND KEY PERSONNEL RESPONSIBILITIES

The project organization for remedial action implementation at IRP Sites 1 and 2 groundwater includes representatives from the DON, BRAC Cleanup Team (BCT), and AECOM-Envirocon Joint Venture (AEJV). The responsibilities of key AEJV personnel are discussed below. The overall organization and relationships of personnel along with lines of communication with DON are illustrated on Figure 8-1.

AEJV is contracted by NAVFAC SW for preparation of the RD/RA WP and to implement RA. The position and responsibilities of key RA contractor team members are as follows:

- **Program Manager.** The program manager is responsible for all aspects of the RA program.
- **Project Manager.** The project manager (PM) has overall responsibility for the RA and all construction work performed during implementation of the RA. Responsibilities include project planning, scheduling, staffing, execution of tasks and subcontracts, and managing deliverables.
- **Program Health and Safety Manager.** The health and safety manager is responsible for developing and implementing the program health and safety plan and project-specific modifications and amendments.
- **Site Safety and Health Officer (SSHO).** The project health and safety officer (SSHO) is responsible for establishing and maintaining communications with all site personnel concerning the site-specific health and safety plan (SSHSP), verifying adherence to site safety requirements, organizing and conducting safety meetings (tailgate meetings), and recording and documenting safety incidents on-site.
- **Project QC Manager.** The project QC Manager is responsible for ensuring that AEJV, subcontractors, and vendors comply with project requirements and contractual obligations, and that all field activities are performed as required by the project design.
- **Project Engineer.** The Project Engineer assists the site superintendent and the program manager by reviewing engineering design documents and interfacing with engineering design personnel and field operations personnel to communicate job requirements.
- **Field Manager.** The Field Manager is responsible for the day-to-day supervision of staff and coordination of tasks for project completion. This includes review of the RD documents, planning and oversight of field activities, QC, and compliance with the Clean Water Act (CWA).
- **Project Chemist.** The project chemist is responsible for ensuring that the field sampling and laboratory analyses are performed in accordance with laboratory and field sampling procedures identified in the Field Sampling Plan and Quality Assurance Project Plan (QAPP).
- **Field, Technical, and Health and Safety Staff.** The Technical Staff will perform QC activities, including subcontractor observation, sampling, testing, and documentation during remedial action implementation. Health and safety personnel will develop and implement the SSHSP. Subcontractor field personnel will perform activities at the site.
- **Senior Technical Advisors.** The Senior Technical Advisors will provide technical advice and review of project documentation during all phases of the project.

8.2 OVERALL IMPLEMENTATION SEQUENCE

The subsections below discuss overall implementation sequence for the ISB systems proposed in the areas where there are uncertainties with respect to the perchlorate extent in groundwater including Source Area PRB, Intermediate PRB, and Station Boundary PRB.

8.2.1 Source Area PRB

As discussed in Section 6.4.1.3, the injection wells for Source Area PRB are intended to stimulate a biologically-reactive zone across the estimated lateral extent of perchlorate exceeding its RG transverse to the direction of groundwater flow (see Figure 6-3). This extent is defined to the northwest by existing well 01-MW205 but is uncertain to the southeast of existing Injection Well 01-IW01 (see Figure 3-1 and 6-3). To manage this uncertainty and to increase the level of confidence that design decisions are made correctly and cost-effectively, the field implementation sequence for Source Area PRB will be based on USEPA's Triad approach. The Triad approach includes three elements: systematic project planning, dynamic work strategies, and real-time measurements. The proposed implementation sequence presented below includes these elements:

1. Complete drilling and installation of Injection Well 01-IW03 (Figure 6-3).
2. Collect baseline a groundwater sample from Well 01-IW03 and analyze it for perchlorate in an off-site laboratory on rapid turn-around time.
3. Analyze perchlorate results based on the following:
   - If perchlorate concentrations are less than or equal to its RG in the groundwater sample, no changes to the PRB design will be required.
   - If perchlorate concentrations exceed its MCL, the following steps will be taken:
     a. Reevaluate perchlorate distribution and modify design as required.
     b. Present revised design to regulatory agencies in a brief field change justification, discuss during the conference call and obtain consensus
     c. Implement revised design and continue to use Triad approach to manage uncertainties.

8.2.2 Intermediate Area PRB

As discussed in Section 6.5.3, the direct push points for Intermediate PRB are intended to stimulate a biologically-reactive zone across the estimated lateral extent of perchlorate exceeding its RG transverse to the direction of groundwater flow (see Figure 6-4). This extent needs to be refined to the northwest of Well 01-PZ15 and to the southeast of Well 01-MW214. Therefore, consistent with Source Area PRB, the following implementation sequence, based on the USEPA's Triad Approach is proposed for the Intermediate PRB:

1. Collect grab groundwater samples using direct-push technology at direct-push locations 01-DPT01, 01-DPT02, 01-DPT14, and 01-DPT15 and analyze for perchlorate in an off-site laboratory on rapid turn-around time.
2. Analyze perchlorate results based on the following:
   - If perchlorate concentrations are less than or equal to its RG in the groundwater sample, no changes to the PRB design will be required.
   - If perchlorate concentrations exceed its MCL in one or more samples, the following steps will be taken:

a. Reevaluate perchlorate distribution and modify design as required. The revised design may include installation of addition direct-push points northwest of location 01-DPT01 and/or southwest of location 01-DPT10.

b. Present revised design to regulatory agencies in a brief field change justification; discuss during the conference call and obtain consensus.

c. Implement revised design and continue to use Triad approach to manage uncertainties.

8.2.3 Station Boundary PRB

As discussed in Section 6.6.3, the injection wells for the Station Boundary PRB are intended to stimulate a biologically-reactive zone across the estimated lateral extent of perchlorate exceeding its RG transverse to the direction of groundwater flow (see Figure 6-6). This extent is defined to the west/northwest by existing well 02NEW30 but is uncertain to the east/northeast of existing well 02PZ12. Therefore, consistent with the Source Area and Intermediate PRBs, the following implementation sequence, based on the USEPA's Triad Approach, is proposed for the Station Boundary PRB:

1. Complete drilling and installation of injection Well 02-IW08 (Figure 6-6).
2. Collect a baseline groundwater sample from Well 02-IW08 and analyze it for perchlorate in an off-site laboratory on rapid turn-around time.
3. Analyze perchlorate results based on the following:
   - If perchlorate concentrations are less than or equal to its RG in the groundwater sample, no changes to the PRB design will be required.
   - If perchlorate concentrations exceed its MCL, the following steps will be taken:
     a. Reevaluate perchlorate distribution and modify design as required. The revised design may include installation of an additional well east of Well 02-IW08.
     b. Present revised design to regulatory agencies in a brief field change justification; discuss during the conference call and obtain consensus.
     c. Implement revised design and continue to use the Triad approach to manage uncertainties.

8.3 REMEDIAL ACTION IMPLEMENTATION PROCEDURES

This section discusses the methods and procedures pertaining to construction activities to be implemented as part of the RA at IRP Sites 1 and 2. The field procedures for sampling and analyses proposed in support of the RA are discussed in the Sampling and Analysis Plan (Attachment A). The RA schedule is presented in Figure 8-2.

8.3.1 Utility Clearance

Utility clearance will be obtained prior to drilling by coordinating with the Navy, FBI, and with City of Irvine/Great Park Corporation (for drilling activities within Carve-Out II-V-2).. Underground utilities in the RA areas will be located by evaluating records including available site plans, utility layouts, and the results of any previous subsurface investigations. A Utility Clearance Request form, along with a map of proposed drilling locations and nearby utilities, will be submitted for approval. Dig Alert will also be notified prior to the start of drilling activities.

8.3.2 Geophysical Surveys and Anomaly Avoidance

Once approval has been obtained from the CSO, a nonintrusive geophysical survey will be conducted at each proposed drilling location at IRP Site 2 and at the Intermediate Area. There are no known subsurface utilities present within IRP Site 1. All geophysical activities will be supervised by a registered geophysicist certified by the State of California.

All proposed well locations will be marked with paint. Electromagnetic induction, ground penetrating radar, and magnetic geophysical techniques will then be used to search for existing underground utilities at the proposed well locations. These complementary techniques are used because underground utilities are made of many different materials (e.g. steel, aluminum, PVC, fiberglass, and cement).

A small grid (about 10 feet by 10 feet) will be constructed at each proposed well location. The grid will consist of one set of parallel profiles oriented approximately north-south and a second set of profiles oriented approximately east-west. Profile lines will be spaced 2 feet to 3 feet apart. Geophysical survey data will be continuously collected along all profiles. Anomalous data zones will be interpreted in real time by the geophysical operators. Locations of anomalies interpreted as representing buried objects will be marked on the ground and posted on the site base map.

Although there are no subsurface utilities present within IRP Site 1, there is a potential for encountering material potentially presenting an explosive hazard (MPPEH). Therefore, anomaly avoidance techniques will be employed to reduce the potential for encountering MPPEH. During anomaly avoidance, an unexploded ordnance (UXO) Technician will use a magnetometer to assist with avoiding MPPEH and other geophysical anomalies. The UXO Technician will first inspect the ground surface of the operational area to ensure that the surface is free of any metallic anomalies before intrusive operations can proceed. This surface inspection will include areas of ingress and egress. At the proposed drilling location, the UXO Technician will first check the location for subsurface anomalies prior to commencing any hand augering or drilling.

After confirming that the location is clear of metallic anomalies, drilling will commence. The first 5 feet of drilling will be conducted using a hand auger. Hand-augering will proceed in 1-foot lifts, and the excavated material will be piled no higher than 1-foot to allow evaluation for metallic anomalies. As hand augering continues, the location will be checked by the UXO Technician at 1-foot intervals until a depth of 5 feet bgs is reached, at which point anomaly avoidance will no longer be required, and the drill rig will be used to advance the remainder of the borehole. During the subsurface anomaly checks, all metallic equipment will be moved far enough away from the excavation location so it does not interfere or mask any metallic subsurface anomalies. If a subsurface anomaly is detected in the borehole, the location will be abandoned and flagged for possible further follow-up. The immediate vicinity will be avoided. The proposed groundwater well will be moved to a nearby point that is clear of all metallic anomalies and hand augering will commence at the new location. No intrusive work will commence until the UXO Technician is satisfied that it is safe to do so. All activities will follow all requirements for anomaly avoidance set forth in the Explosives Safety Submission (ESS) for the site to be developed in the future.

8.3.3 Natural Resources Coordination

The Draft RA WP was submitted to the United States Fish and Wildlife Service (USFWS) in June 2012. This Draft WP included environmental impact minimization measures presented below for review and comment by the USFWS.

Coastal sage scrub (CSS) has been observed at IRP Sites 1 and 2. Figures 8-3 and 8-4 present the results of previous CSS mapping conducted in 2000 for IRP Sites 1 (Lincer & Associates 2001) and 2 (Earth Tech and Lincer 2001), respectively. As shown on Figure 8-3 (IRP Site 1), some CSS may be near paths of ingress/egress for several existing wells that will receive injections; however, there are no proposed new wells near CSS locations. At IRP Site 2, Figure 8-4 shows that CSS and mule fat scrub is adjacent to some drilling locations, and ingress/egress concerns may necessitate the trimming of some CSS to allow passage of drilling equipment. Less than 1/10th of an acre will require trimming to facilitate the installation of the four injection wells. Additionally, the proposed well drilling and substrate injection operations may have the potential to affect the coastal California gnatcatcher (CAGN), birds protected by the Migratory Bird Treaty Act (MBTA) (if present) and other sensitive species or their habitat. However, it is anticipated that the RA activities will have a negligible effect on CSS, the CAGN, and other sensitive species or their habitat because the following environmental impact minimization measures will be implemented during the field activities:

- A qualified biological monitor, familiar with the ecology of the CAGN and possessing a Federal 10(a)(1)(A) permit for the CAGN, will be responsible for overseeing any activities that could disturb the CAGN within the project area.
- If the CAGN or any birds protected by the MBTA are found to be nesting, said nests will be marked by the biological monitor for avoidance during field activities, if work occurs during the breeding season.
- The qualified biological monitor will have the authority to suspend any activities within the project site that have the potential to adversely affect nesting CAGN. All such activities will be postponed if they are found to occur within 200 feet of an active nest and will not resume until young have fledged and are sufficiently mobile to readily follow their parents, and evade disturbances.
- Efforts will be made to minimize impacts to habitat by trimming vegetation to the extent possible, rather than excavation and grading.
- After completion of the RA, a report of monitoring activities and results will be prepared and submitted to the USFWS.

8.3.4 Compliance with Nationwide Permit 38

The definition of the discharge of fill material per 40 C.F.R. Section 232.2 includes the building of any structure or infrastructure requiring sand, dirt or other material for its construction. The implementation of the remedial actions for IRP Site 1 perchlorate-impacted groundwater and IRP Site 2 VOC-impacted groundwater may lead to discharge of fill material (as defined at 40 C.F.R. § 232.2) into waters of the United States. The discharge of fill material will comply with substantive provisions of the Nationwide Permit (NWP) 38 issued by the United States Army Corps of Engineers (USACE) (Federal Register 2012). The CERCLA response actions are not required to obtain permits as provided in 42 U.S.C. § 9621(e). Below is the text of NWP No. 38:

> ***Nationwide Permit No. 38. Cleanup of Hazardous and Toxic Waste.*** Specific activities required to effect the containment, stabilization, or removal of hazardous or toxic waste materials that are preformed, ordered, or sponsored by a government agency with established legal or regulatory authority. Court ordered remedial action plans or related settlements are also authorized by this NWP. This NWP does not authorize the establishment of new disposal sites or the expansion of existing sites used for the disposal of hazardous or toxic waste.

> ***Note:*** Activities undertaken entirely on a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site by authority of CERCLA as approved or required by EPA, are not required to obtain permits under Section 404 of the Clean Water Act or Section 10 of the Rivers and Harbors Act.

The remedial actions for groundwater at IRP Sites 1 and 2 will comply with substantive requirements of the General Conditions of the 2012 NWPs. Table 8-1 lists the applicable General Conditions and how the project will comply with the requirements.

Migratory birds, and endangered species and their habitats will be protected by complying with substantive requirement of MBTA and Endangered Species Act as discussed in Section 8.3.3. Soil erosion/sediment control will be implemented during construction activities. Soil cuttings generated from borehole drilling will be placed in plastic-lined rolloff bins at the site (see Section 8.3.9.1 for details). To the extent practicable, and in compliance with the NWP General Conditions, the injection/monitoring wells will not change pre-construction course, condition, capacity, and location of Borrego Canyon Wash and its tributaries. Any impacts on the condition of Borrego Canyon Wash are anticipated to be negligible, as most impacts are temporary in nature and relate to equipment access within the channel and adjacent floodplain areas.

8.3.5 Drilling and Well Installation

All drilling and well installation activities will be supervised by a California-registered geologist. Monitoring and injection well installation and development methods will follow AEJV SOP 3-12, Well Installation and Destruction (AEJV 2012).

8.3.5.1 Direct-Push Drilling

A total of 10 injection points will be advanced by direct-push techniques in support of the PRB at the Intermediate Area. Direct-push drilling will be conducted in accordance with AEJV SOP 3-12, Well Installation and Destruction (AEJV 2012).

8.3.5.2 Hollow-Stem Auger Drilling

The following wells will be installed at IRP Site 1, the Intermediate Area, and IRP Site 2, using hollow-stem auger (HSA) techniques:

IRP Site 1 Source Area PRB:

- 2 injection wells
- 2 monitoring wells

IRP Site 1 Source Area:

- 10 injection wells
- 5 extraction wells

Intermediate Area PRB:

- 4 monitoring wells

Station Boundary PRB:

- 7 injection wells
- 5 monitoring wells

For MNA:

- 3 monitoring wells

The proposed well locations are presented on Figures 6-4, 6-5, and 6-6, and screen intervals are presented in Tables 6-3, 6-6, 6-8, and 6-10. Eight-inch diameter augers will be used to drill all boreholes. Drilling will be conducted in accordance with AEJV 3-12, Well Installation and Destruction (AEJV 2012).

8.3.5.3 Well Installation

All injection/extraction wells will be completed with 2-inch diameter Schedule 80 PVC well screen and blank casing. All monitoring wells will be completed with 4-inch diameter Schedule 40 PVC well screen and blank casing. Figure 8-5 presents typical construction details for monitoring and injection/extraction wells.

Based on previous well installation at IRP Sites 1 and 2, all wells will be completed using 0.02-inch slot well screen and Lone Star #3 sand filter pack material. All well casings will be sealed at the bottom with a flush threaded end cap of the same material as the well screen. Screen and blank riser sections will be steam cleaned and wrapped in plastic for transportation to the well locations. The casing will remain wrapped in plastic until it is assembled and lowered down the borehole.

The well casing will be plumb and centered with centralizers placed every 20 feet, if necessary. Once the casing is installed, the filter pack, consisting of acid-resistant, washed and graded silica sand, will be placed by tremie pipe down the annulus between the well casing and the borehole wall. The sand will be furnished in sacks and will be certified clean and free of oil, acids, and organic and other deleterious materials. The filter pack will be placed from the bottom of the borehole to 2 feet above the top of the well screen or between the bentonite seals for the multi-screen wells. The filter pack depth will be periodically sounded to monitor the depth and to locate any points of bridging between the well casing and the borehole wall. Potable water may be poured down the annulus to break bridges if they are encountered. The amount of water introduced into the well will be kept to a minimum and the quantities will be recorded in the field logbook.

The volume of filter pack material used will be recorded in the field logbook during filter pack construction. The volume of sand used will be compared to the volume of annulus filled every 5 feet to 10 feet. If a significant discrepancy arises between the sand volume used versus the filled volume measured, the source of this error will be identified and corrected.

Wells will be predeveloped by bailing and surging to aid in settling the filter pack before placing the bentonite seal. After the filter pack has been placed, a 2-foot to 5-foot sodium bentonite seal (either granular for unsaturated conditions or coated pellet form for saturated conditions) will be introduced into the well above the filter pack. The bentonite will be saturated with potable water and allowed to hydrate for at least 1 hour. After the bentonite seal has hydrated, the remaining annulus will be grouted using a Type I Portland or American Petroleum Institute (API) Class A cement/bentonite slurry.

8.3.5.4 Well Development

Each newly-installed well will be developed no sooner than 24 hours following well completion in accordance with AEJV SOP 3-12, Well Installation and Destruction (AEJV 2012).

8.3.5.5 Armoring of Wells Installed in Borrego Canyon Wash

Due to the extremely high water flow conditions that occasionally occur within Borrego Canyon Wash near the proposed Station Boundary PRB, additional armoring is proposed to prevent damages. A 24-inch diameter steel casing is proposed to be advanced using air-knife techniques to a depth of 4 feet bgs. The casing will stick up to the height of the monitoring well monument. Within that outer casing, a 10-inch steel casing will be advanced to a depth of 18 feet bgs. The injection or monitoring well will then be installed within the 12-inch steel casing. A diagram of the proposed design is shown on Figure 8-6.

8.3.6 Amendment Procurement and Storage

The substrate will be delivered to the site in 1,000-liter totes. Because it is a more secure location, the staging area for the totes will be within IRP Site 1. When needed for injection activities, the totes will be moved on pallets using a backhoe.

8.3.7 Substrate Injection Process and Equipment

The substrate will be amended to the subsurface by introducing a volume of water containing the desired concentration to a well or set of wells. A minimal amount of that water will come from extraction at wells near the injection wells. The remainder will be provided by a hydrant located between IRP Sites 1 and 2. A water truck will transport the hydrant water to on-site tanks.

8.3.8 Location Survey

Each newly-installed well and direct-push injection point will be referenced to standard horizontal control and vertical control by a California-licensed land surveyor. For wells, the measuring point will be clearly and permanently marked on the northern side of the inside well casing for future water level measurements. Vertical elevations of the casings and elevations of the ground surface will be measured to the nearest 0.01-foot, referenced to msl. The horizontal location will be measured to the nearest 0.1-foot, referenced to msl. All points will be surveyed to North American Datum 83 California State Plane Coordinate System Zone 6 for horizontal control, and National American Vertical Datum 88 for vertical datum, including translation into latitude and longitude coordinates (horizontal datum).

8.3.9 Remediation-Derived Waste Management

All remediation-derived waste will be managed appropriately. Remediation-derived waste includes the following:

- Cuttings from injection and monitoring well boreholes
- Groundwater generated from development of new wells
- Groundwater generated from purging of wells prior to sampling
- Decontamination fluids
- Disposable protective clothing and supplies.

Procedures for handling these wastes are discussed in the following sections.

8.3.9.1 SOIL

Soil cuttings generated during borehole drilling will be placed in plastic-lined rolloff bins at the site. All rolloff bins will be labeled with borehole or well number, depth interval, date generated, and contents. To obtain representative samples, a composite sample from each rolloff bin will be analyzed for contaminants historically reported in soil at the site. If VOC analysis is required, two discrete samples will be collected from each rolloff bin. The composite sample will be collected as follows: approximately equal amounts of soil will be removed from four areas within the rolloff bin using a stainless steel trowel and placed in a stainless steel bowl; the soil will be mixed in the bowl; the mixed soil will then be placed in an 8-ounce glass jar and prepared for shipment to the laboratory.

Analytical results will be compared with regulatory criteria and standards to assess if the sampled material can be returned to the site or must be disposed at an approved waste facility as either nonhazardous or hazardous waste.

8.3.9.2 WELL DEVELOPMENT/PURGE WATER AND DECONTAMINATION FLUIDS

Water purged from wells during well development or during decontamination of drilling equipment will be placed in 55-gallon drums. Composite samples will be collected from not more than four drums each, and analyzed for contaminants historically reported in groundwater at the site. Analytical results will be compared with regulatory criteria and standards to assess if the sampled water will be disposed off-site at an approved waste facility as either nonhazardous or hazardous waste.

8.3.9.3 DISPOSABLE PROTECTIVE CLOTHING

All disposable protective clothing and supplies will be presumed non-hazardous and will be disposed as nonhazardous waste at an appropriate waste facility.

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Figures

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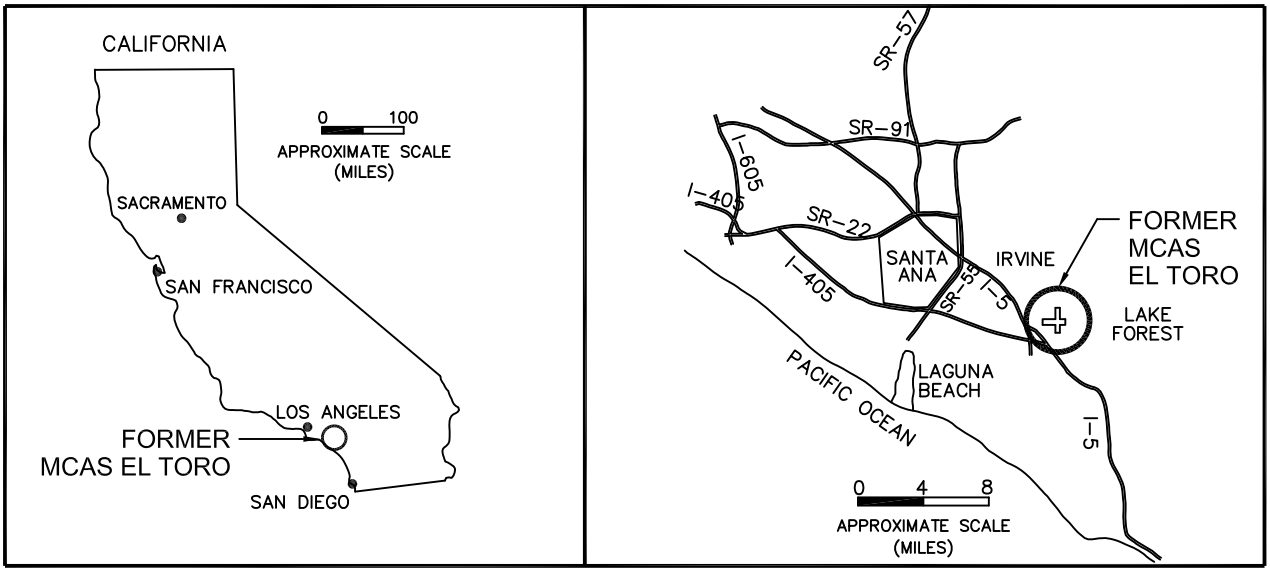
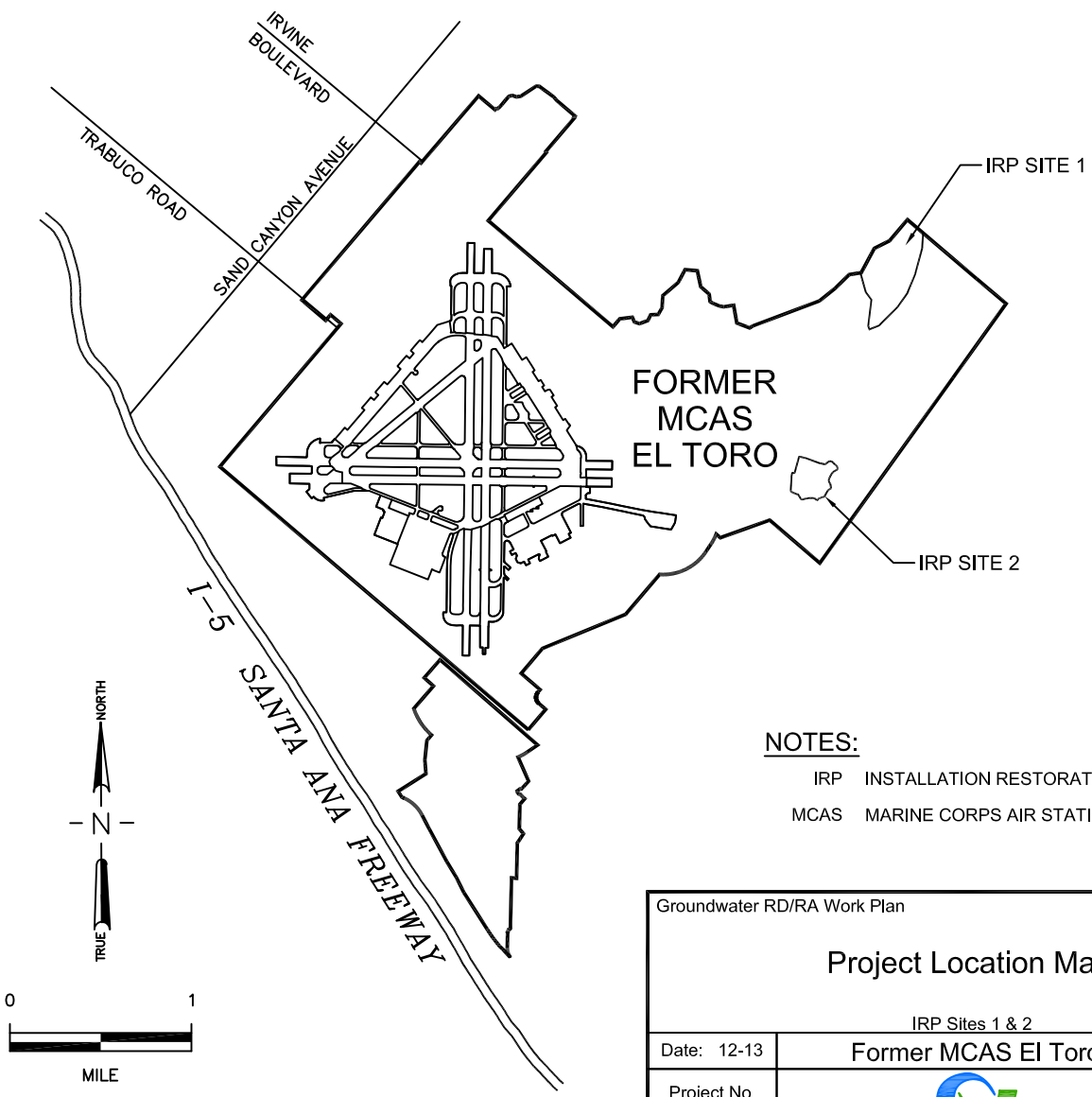




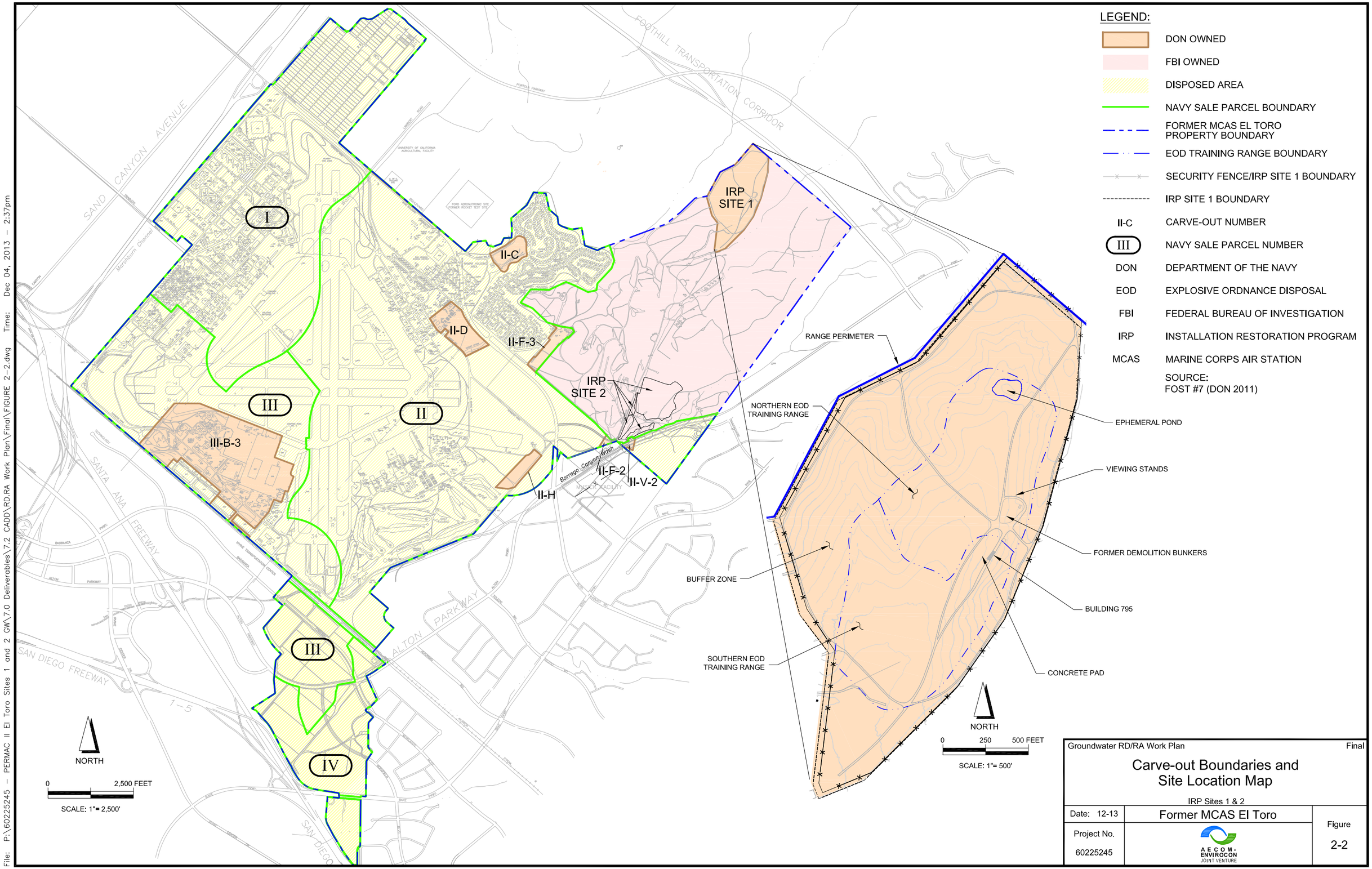
NOTES:

IRP INSTALLATION RESTORATION PROGRAM

MCAS MARINE CORPS AIR STATION

Groundwater RD/RA Work Plan		Final
Project Location Map IRP Sites 1 & 2		
Date: 12-13	Former MCAS El Toro	Figure
Project No. 60225245	AECOM-ENVIROCON JOINT VENTURE	2-1

File: P:\60225245 – PERMAC II El Toro Sites 1 and 2 GW\7.0 Deliverables\7.2 CADD\RD.RA Work Plan\Final\FIGURE 2-1.dwg Time: Dec 04, 2013 – 2:32pm



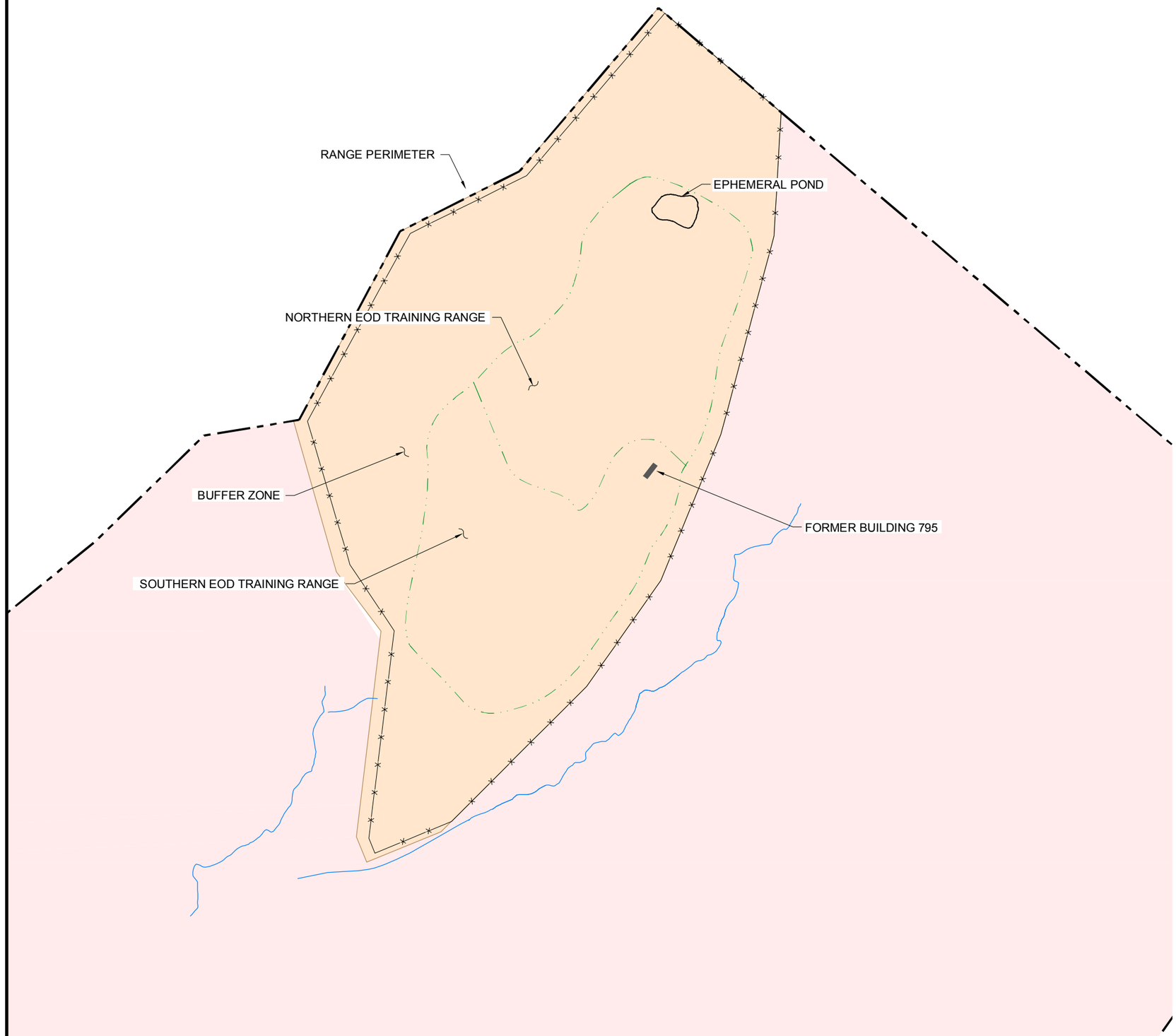
Groundwater RD/RA Work Plan — Final

Carve-out Boundaries and Site Location Map

IRP Sites 1 & 2

Date: 12-13	Former MCAS El Toro	Figure
Project No. 60225245	AECOM-ENVIROCON JOINT VENTURE	2-2

File: P:\60225245 – PERMAC II El Toro Sites 1 and 2 GW\7.0 Deliverables\7.2 CADD\RD.RA Work Plan\Final\FIGURE 2-2.dwg Time: Dec 04, 2013 – 2:37pm



LEGEND

- MCAS EL TORO BOUNDARY
- SECURITY FENCE/ IRP SITE 1 BOUNDARY
- EXPLOSIVE ORDNANCE DISPOSAL (EOD) TRAINING RANGE BOUNDARY
- STREAM OR WASH
- DON OWNED
- FBI OWNED

NOTES

DON	DEPARTMENT OF THE NAVY
FBI	FEDERAL BUREAU OF INVESTIGATION
IRP	INSTALLATION RESTORATION PROGRAM
MCAS	MARINE CORPS AIR STATION

NORTH

0 200 400 FEET

SCALE: 1" = 400'

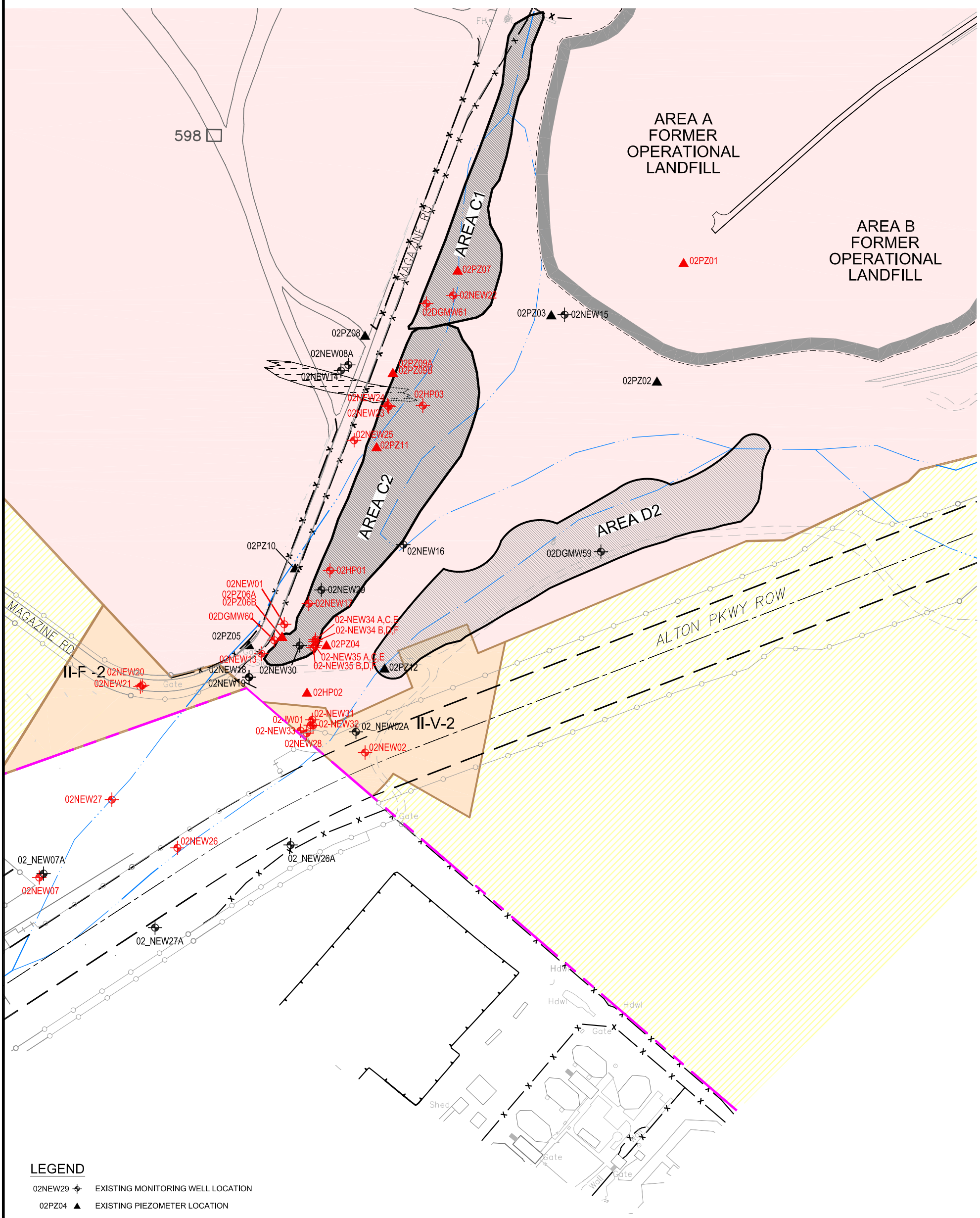
Groundwater RD/RA Work Plan — Final

Site Plan - IRP Site 1

IRP Sites 1 & 2

Date: 12-13	Former MCAS El Toro	Figure
Project No. 60225245	AECOM-ENVIROCON JOINT VENTURE	2-3

File: P:\60225245 – PERMAC II El Toro Sites 1 and 2 GW\7.0 Deliverables\7.2 CADD\RD.RA Work Plan\Final\FIGURE 2–3.dwg Time: Dec 04, 2013 – 2:40pm



LEGEND

- 02NEW29 — EXISTING MONITORING WELL LOCATION
- 02PZ04 — EXISTING PIEZOMETER LOCATION
- 02NEW01 — ABANDONED/DESTROYED MONITORING WELL LOCATION
- 02PZ11 — ABANDONED/DESTROYED PIEZOMETER LOCATION
- FORMER MCAS EL TORO BOUNDARY
- IRP SITE 2 BOUNDARY
- 6-FT CHAIN LINK FENCE
- IMPROVED ROADS
- UNIMPROVED ROADS
- II-V-2 — CARVE-OUT NUMBER
- FORMER DISPOSAL LOCATIONS CONSOLIDATED INTO FORMER OPERATIONAL LANDFILL
- DON OWNED
- FBI OWNED
- TRANSFERRED AREA
- INFERRED LOWER HYDRAULIC CONDUCTIVITY ZONE WITHIN BEDROCK

NOTES

DON	DEPARTMENT OF THE NAVY
EOD	EXPLOSIVE ORDNANCE DISPOSAL
FBI	FEDERAL BUREAU OF INVESTIGATION
FT	FOOT
IRP	INSTALLATION RESTORATION PROGRAM
MCAS	MARINE CORPS AIR STATION
PKWY	PARKWAY
RD	ROAD
ROW	RIGHT OF WAY

NORTH

0 100 200 FEET

SCALE: 1" = 200'

Groundwater RD/RA Work Plan — Final

Site Plan - IRP Site 2
Magazine Road Landfill

IRP Sites 1 & 2

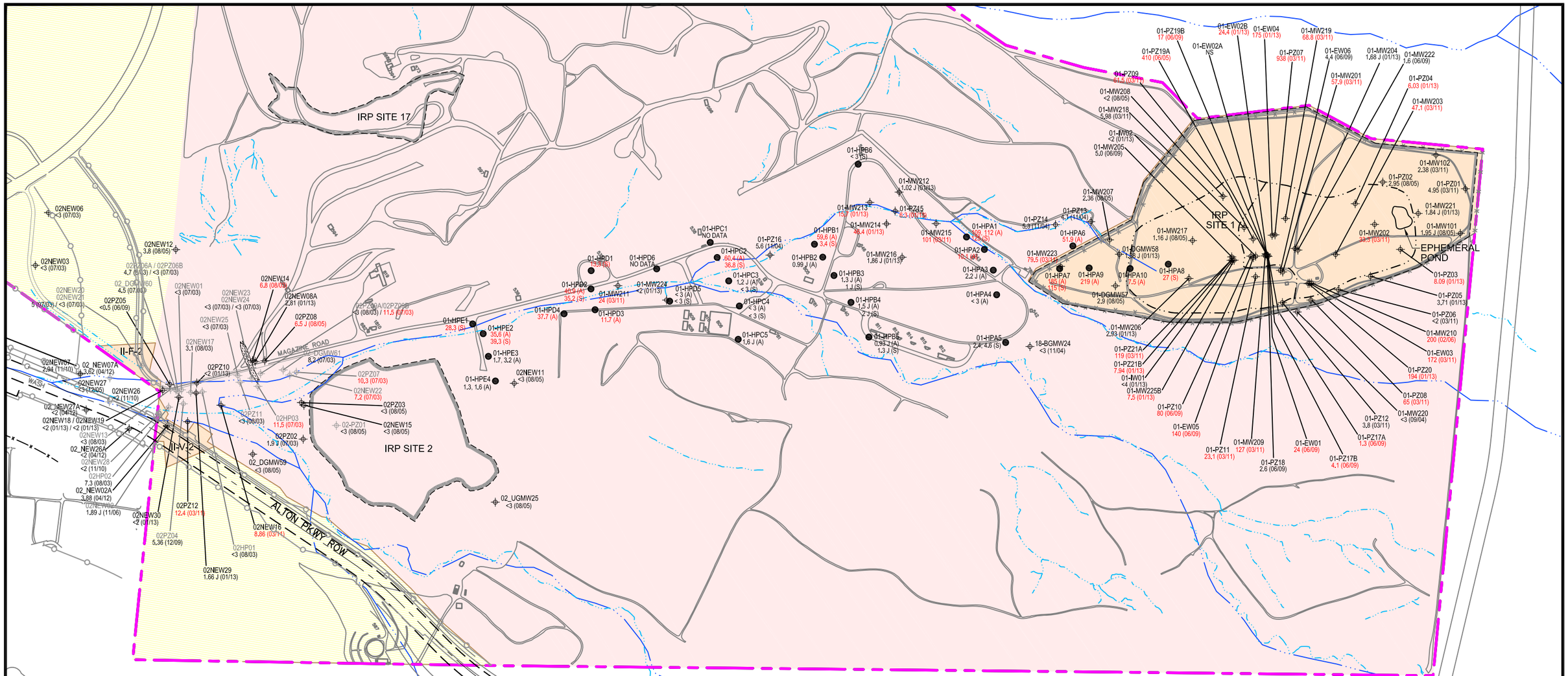
Former MCAS El Toro

Date: 12-13

Project No. 60225245

AECOM-ENVIROCON JOINT VENTURE

Figure 2-4



LEGEND:

01-HPE4 ●	HYDROPUNCH SAMPLING LOCATION
1.6 J (A) < 3 (S) J	HYDROPUNCH PERCHLORATE CONCENTRATION IN µg/L, RED INDICATES GREATER THEN 6 µg/L (A INDICATES ALLUVIUM SAMPLE, S INDICATES WEATHERED BEDROCK SAMPLE, J INDICATES ESTIMATED VALUE)
01-MW201	EXISTING 4-INCH GROUNDWATER MONITORING WELL (OR 2-INCH PIEZOMETER), PERCHLORATE CONCENTRATION IN µg/L (RED INDICATES GREATER THAN 6 µg/L)
02-NEW01	ABANDONED/DESTROYED 4-INCH GROUNDWATER MONITORING WELL (OR 2-INCH PIEZOMETER), PERCHLORATE CONCENTRATION IN µg/L (RED INDICATES GREATER THAN 6 µg/L)
	MCAS EL TORO BOUNDARY
	EOD RANGE BOUNDARY
	IRP SITE BOUNDARY (1, 2, AND 17)
	EPHEMERAL STREAM OR WASH (INTERPOLATED FROM TOPOGRAPHIC DATA)
	6-FOOT CHAIN-LINK FENCE
	10-FOOT SECURITY FENCE
	DON OWNED
	FBI OWNED
	TRANSFERRED AREA
II-V-2	CARVE-OUT NUMBER

NOTES:

1. FOR EACH WELL/SAMPLING LOCATION, THE LATEST AVAILABLE PERCHLORATE CONCENTRATION DATA IS REPORTED BASED ON THE FOLLOWING REPORTS/ SAMPLE EVENTS SPRING 2011 SUMMARY REPORT, IRP SITES 1 AND 2 (TREVET 2011); TECHNICAL MEMORANDUM, IN-SITU BIOREMEDIATION PILOT STUDY, IRP SITE 1 (AECOM AND ECS 2011); FINAL GROUNDWATER FEASIBILITY STUDY, IRP SITES 1 AND 2 (AECOM 2011); AND SUPPLEMENTAL GROUNDWATER MONITORING, JANUARY 2013.

<	LESS THAN
µg/L	MICROGRAMS PER LITER
DON	DEPARTMENT OF THE NAVY
EOD	EXPLOSIVE ORDNANCE DISPOSAL
FBI	FEDERAL BUREAU OF INVESTIGATION
IRP	INSTALLATION RESTORATION PROGRAM
MCAS	MARINE CORPS AIR STATION
NS	NOT SAMPLED
RI	REMEDIAL INVESTIGATION
ROW	RIGHT-OF-WAY

NORTH

0 350 700 FEET

SCALE: 1" = 700'

Groundwater RD/RA Work Plan — Final

Perchlorate Concentrations in Groundwater

IRP Sites 1 & 2

Date: 12-13

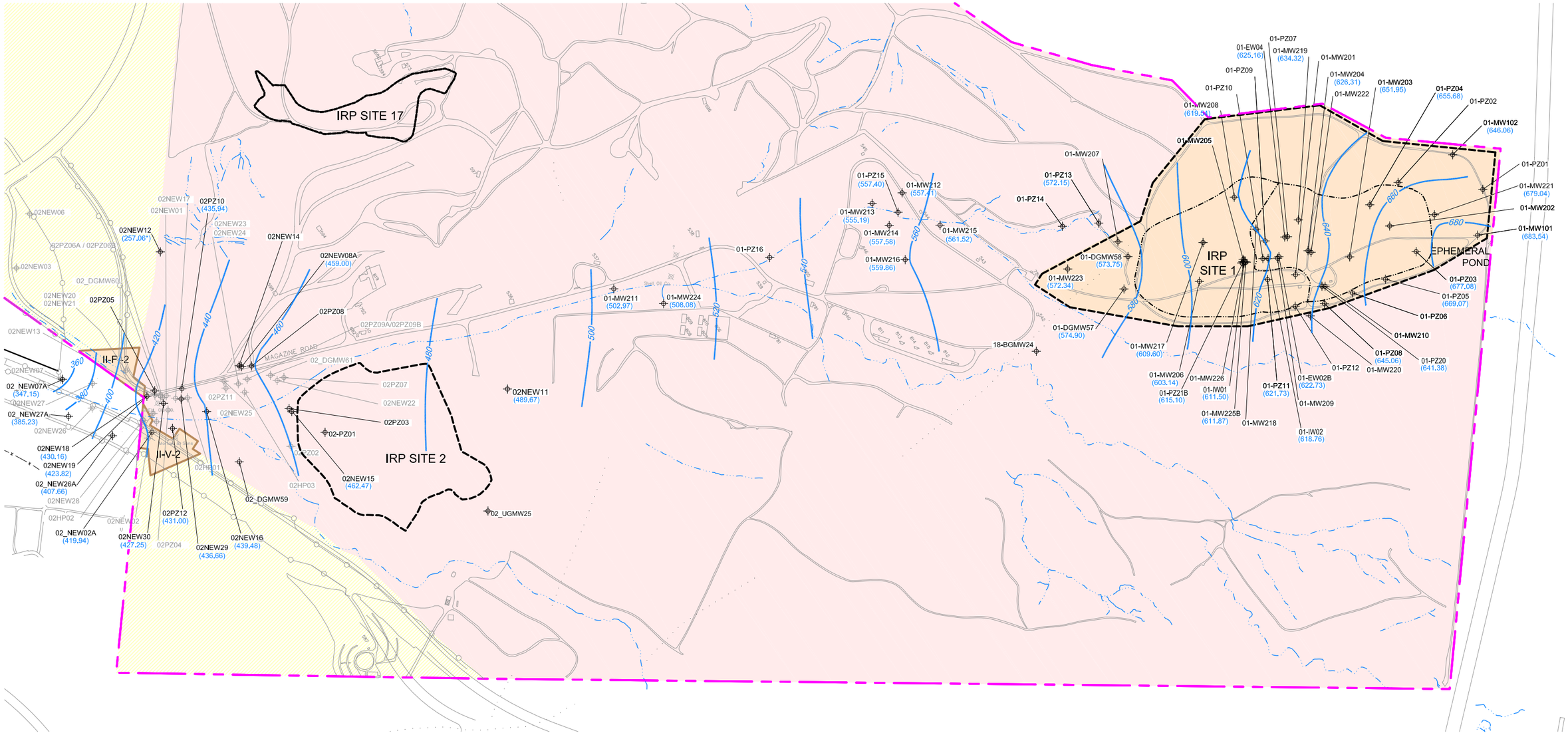
Former MCAS El Toro

Project No. 60225245

AECOM-ENVIROCON JOINT VENTURE

Figure 3-1

File: P:\60225245 – PERMAC II El Toro Sites 1 and 2 GW\7.0 Deliverables\7.2 CADD\RD.RA Work Plan\Final\FIGURE 3-1A.dwg Time: Dec 04, 2013 – 2:51pm



LEGEND:

- 01-MW209 / 01-PZ11 — EXISTING 4-INCH GROUNDWATER MONITORING WELL WITH CORRESPONDING GROUNDWATER ELEVATION (OR 2-INCH PIEZOMETER)
- 02NEW01 / 02PZ11 — ABANDONED/DESTROYED 4-INCH GROUNDWATER MONITORING WELL (OR 2-INCH PIEZOMETER)
- MCAS EL TORO BOUNDARY
- EOD TRAINING RANGE BOUNDARY
- IRP SITE BOUNDARY (1, 2 AND 17)
- STREAM OR WASH (INTERPOLATED FROM TOPOGRAPHIC DATA)
- 500 — GROUNDWATER CONTOUR ELEVATION, DASHED WHERE INFERRED (GROUNDWATER ELEVATIONS COLLECTED ON JANUARY 8 AND 9, 2013)
- 6-FOOT CHAIN-LINK FENCE
- 10-FOOT SECURITY FENCE
- DON OWNED
- FBI OWNED
- TRANSFERRED AREA
- II-V-2 — CARVE-OUT NUMBER
- INFERRED LOWER HYDRAULIC CONDUCTIVITY ZONE WITHIN BEDROCK

NOTES:

DON	DEPARTMENT OF THE NAVY
EOD	EXPLOSIVE ORDNANCE DISPOSAL
FBI	FEDERAL BUREAU OF INVESTIGATION
IRP	INSTALLATION RESTORATION PROGRAM
MCAS	MARINE CORPS AIR STATION

* GROUNDWATER ELEVATION FROM 02-NEW-12 NOT USED FOR CONTOURING. THIS WELL IS SCREENED IN A DEEPER HYDROGEOLOGIC UNIT.

NORTH

0 350 700 FEET

SCALE: 1"= 700'

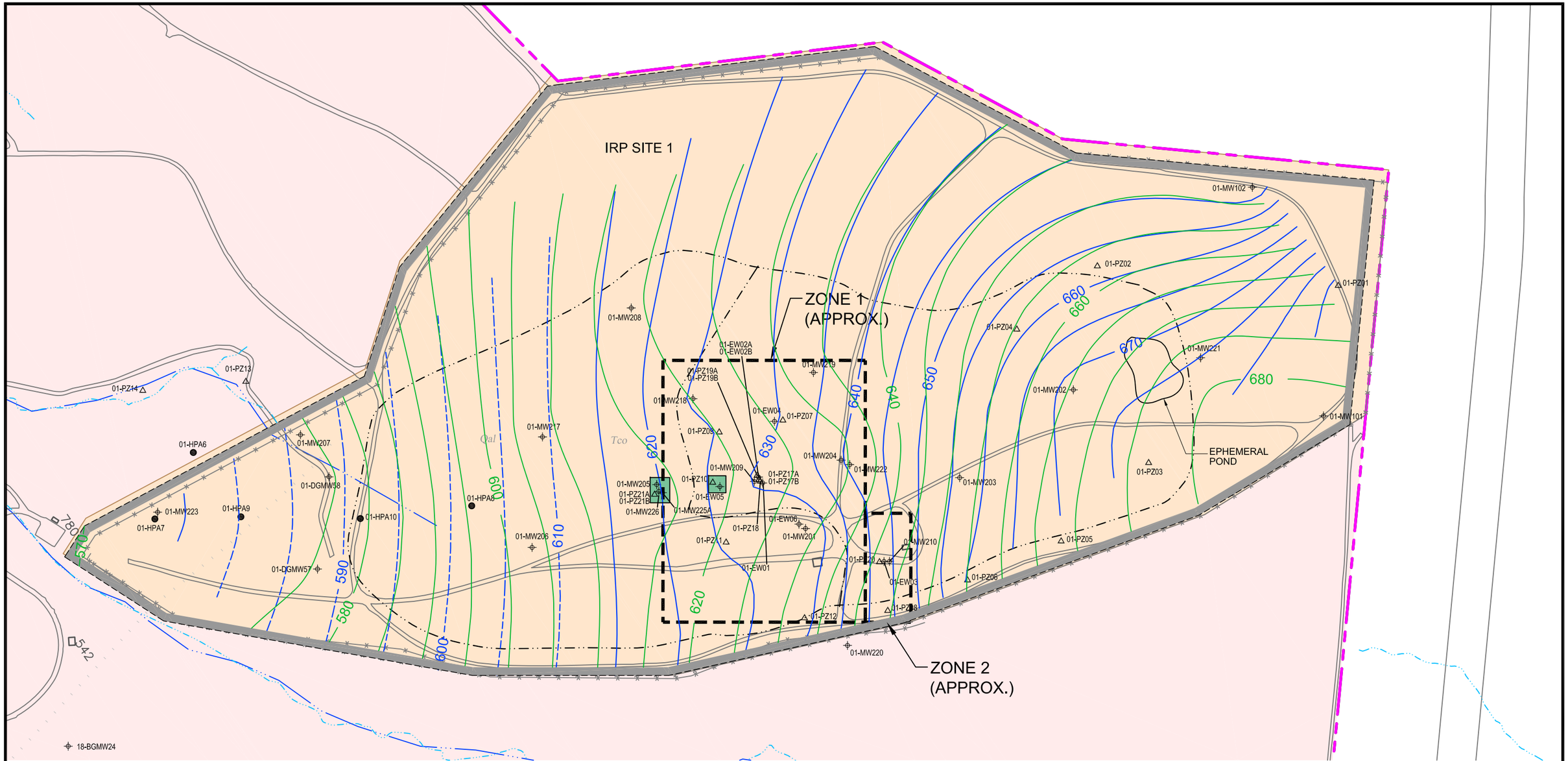
Groundwater RD/RA Work Plan — Final

Groundwater Equipotential Map (January 2013)

IRP Sites 1 & 2

Date: 12-13	Former MCAS El Toro	Figure
Project No. 60225245	AECOM-ENVIROCON JOINT VENTURE	3-2

File: P:\60225245 – PERMAC II El Toro Sites 1 and 2 GW\7.0 Deliverables\7.2 CADD\RD.RA Work Plan\Final\FIGURE 3–2.dwg Time: Dec 04, 2013 – 2:56pm



LEGEND:

- 01-HPE4 — HYDROPUNCH SAMPLING LOCATION
- 01-MW206 — GROUNDWATER MONITORING WELL
- 01-PZ02 — 2-INCH PIEZOMETER
- 640 — GROUNDWATER EQUIPOTENTIAL CONTOUR, MARCH 2011 (FEET ABOVE MSL), DASHED WHERE INFERRED
- 635 — GROUNDWATER EQUIPOTENTIAL CONTOUR, JANUARY 2013 (FEET ABOVE MSL), DASHED WHERE INFERRED
- APPROXIMATE BOUNDARY OF HYDROGEOLOGIC ZONES (ECS 2006)
- MCAS EL TORO BOUNDARY
- EOD RANGE BOUNDARY
- IRP SITE BOUNDARY
- EPHEMERAL STREAM OR WASH (INTERPOLATED FROM TOPOGRAPHIC DATA)
- EXISTING FENCE
- DON OWNED
- FBI OWNED
- 2009-2010 ISB PILOT STUDY LOCATIONS

NOTES:

DON	DEPARTMENT OF THE NAVY
FBI	FEDERAL BUREAU OF INVESTIGATION
IRP	INSTALLATION RESTORATION PROGRAM
ISB	IN SITU BIOREMEDIATION
MCAS	MARINE CORPS AIR STATION
MSL	MEAN SEA LEVEL

NORTH

0 120 240 FEET

SCALE: 1" = 240'

Data Source: Spring 2011 Data Summary Report, July 2011 (Trevet 2011)

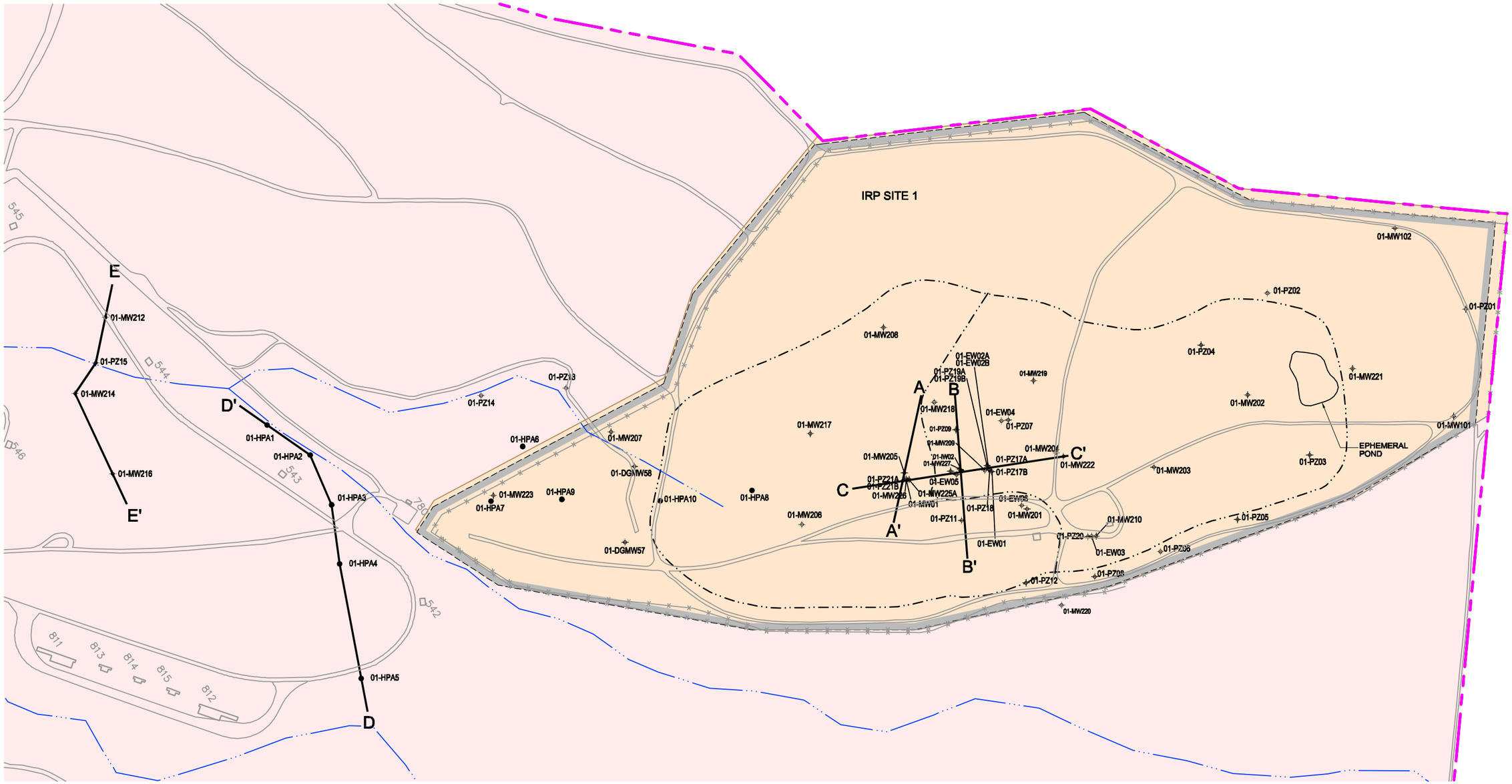
Groundwater RD/RA Work Plan — Final

Groundwater Equipotential Map IRP Site 1 (March 2011 and January 2013)

IRP Sites 1 & 2

Date: 12-13	Former MCAS El Toro	Figure
Project No. 60225245	AECOM-ENVIROCON JOINT VENTURE	3-3

File: P:\60225245 – PERMAC II El Toro Sites 1 and 2 GW\7.0 Deliverables\7.2 CADD\RD.RA Work Plan\Final\FIGURE 3-3.dwg Time: Dec 10, 2013 – 9:17am



LEGEND:

- 01-HPE4 ● HYDROPUNCH SAMPLING LOCATION
- 01-MW206 ⌖ 4 - INCH GROUNDWATER MONITORING WELL OR 2 - INCH PIEZOMETER
- EXISTING BUILDING/STRUCTURE
- EXISTING ROAD
- MCAS EL TORO BOUNDARY
- EOD RANGE BOUNDARY
- A——A' CROSS SECTION LOCATION
- IRP SITE BOUNDARY
- EPHEMERAL STREAM OR WASH (INTERPOLATED FROM TOPOGRAPHIC DATA)
- EXISTING FENCE
- DON OWNED
- FBI OWNED

NOTES:

DON	DEPARTMENT OF THE NAVY
EOD	EXPLOSIVE ORDNANCE DISPOSAL
FBI	FEDERAL BUREAU OF INVESTIGATION
IRP	INSTALLATION RESTORATION PROGRAM
MCAS	MARINE CORPS AIR STATION

NORTH

0 150 300 FEET

SCALE: 1" = 300'

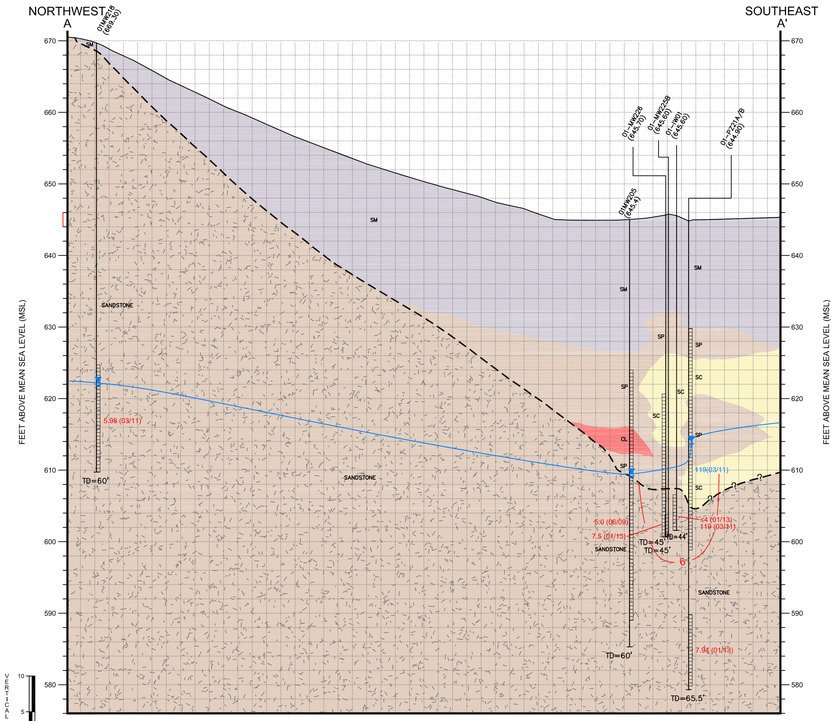
Data Source:
March 2009 Stationwide Groundwater Monitoring (Trevet 2010) & June 2009 Pre-Baseline Sampling. ECS-Aecom

Groundwater RD/RA Work Plan — Final

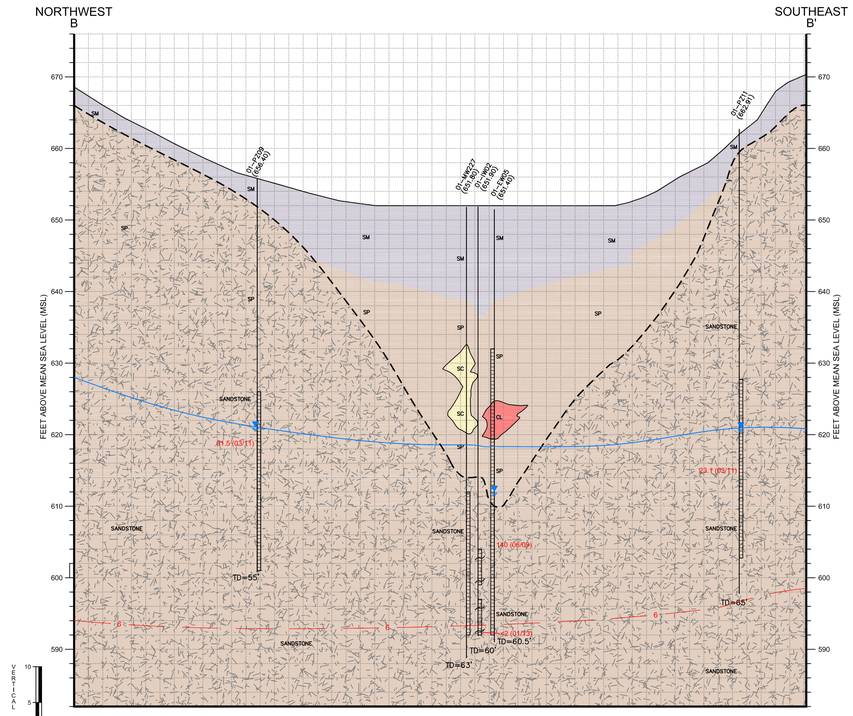
Cross Section Locations
IRP Site 1 and Intermediate Area

Date: 12-13	Former MCAS El Toro	Figure
Project No. 60225245	AECOM-ENVIROCON JOINT VENTURE	3-4

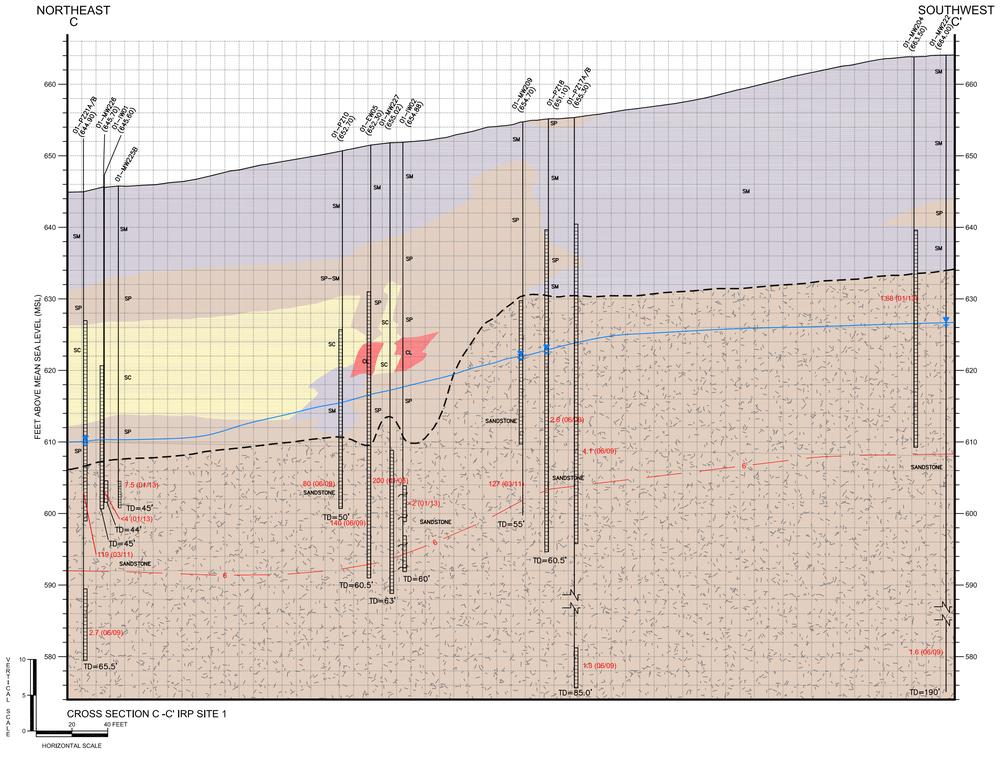
File: P:\60225245 - PERMAC II El Toro Sites 1 and 2 GW\7.0 Deliverables\7.2 CADD\RD.RA Work Plan\Final\FIGURE 3-4.dwg Layout: Figure 3-5 User: carrillo1 Plotted: Dec 04, 2013 - 3:02pm



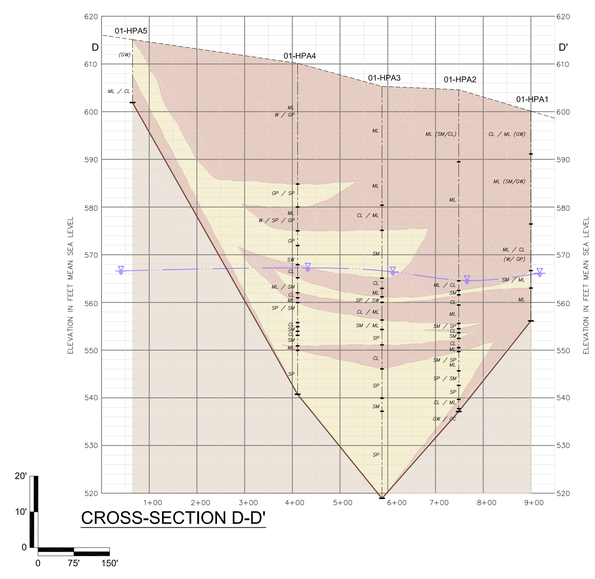
CROSS SECTION A -A' IRP SITE 1



CROSS SECTION B -B' IRP SITE 1



CROSS SECTION C -C' IRP SITE 1



CROSS-SECTION D-D'

LEGEND:

- 01-HPE4 — HYDROPUNCH SAMPLING LOCATION
- 01-MW206 — GROUNDWATER MONITORING WELL
- 01-PZ02 — 2-INCH PIEZOMETER
- EXISTING BUILDINGS/STRUCTURE
- EXISTING ROAD
- 660 — ELEVATION CONTOUR
- GENERAL GROUNDWATER FLOW DIRECTION
- MCAS EL TORO BOUNDARY
- EOD RANGE BOUNDARY
- IRP SITE BOUNDARY
- EPHEMERAL STREAM OR WASH (INTERPOLATED FROM TOPOGRAPHIC DATA)
- GEOLOGIC FAULT, DOTTED WHERE INFERRED
- EXISTING FENCE
- 6 — PERCHLORATE ISO - CONCENTRATION CONTOUR

CROSS SECTIONS

- 01-PZ10 (650.70) — WELL ID (GROUND SURFACE ELEVATION ABOVE MSL)
- GROUND SURFACE
- MONITORING/EXTRACTION/INJECTION WELL
- GROUNDWATER TABLE ELEVATION (JANUARY 2013)
- ALLUVIAL / BEDROCK CONTACT
- SCREENED INTERVAL
- 1.6 J (12/05) — FRACTURE INITIATION DEPTH - PILOT STUDY
- PERCHLORATE CONCENTRATION IN GROUNDWATER IN MICROGRAMS PER LITER (µg/L (DATE) (J INDICATES ESTIMATED VALUE)
- TD=50' — TOTAL DEPTH (BGS)

LITHOLOGY (CROSS SECTION A-A', B-B', AND C-C')

- CL - CLAY, SANDY CLAY, SILTY CLAY
- SC - CLAYEY SAND
- SM - SILTY SAND
- SP - POORLY GRADED SAND
- SANDSTONE

LITHOLOGY (CROSS SECTION D-D')

- CL - CLAY, SANDY CLAY, SILTY CLAY
- SP - POORLY GRADED SAND
- SANDSTONE

NOTES:

EOD	EXPLOSIVE ORDNANCE DISPOSAL
IRP	INSTALLATION RESTORATION PROGRAM
MCAS	MARINE CORPS AIR STATION
MSL	MEAN SEA LEVEL

EXPLANATION

'	FEET
µg/L	MICROGRAMS PER LITER
BGS	BELOW GROUND SURFACE
EOD	EXPLOSIVE ORDNANCE DISPOSAL
ID	IDENTIFICATION
IRP	INSTALLATION RESTORATION PROGRAM
MCAS	MARINE CORPS AIR STATION
MSL	MEAN SEA LEVEL
TD	TOTAL DEPTH

Data Source:
March 2009 Stationwide Groundwater Monitoring (Trevet 2010) & June 2009 Pre-Baseline/Sampling.

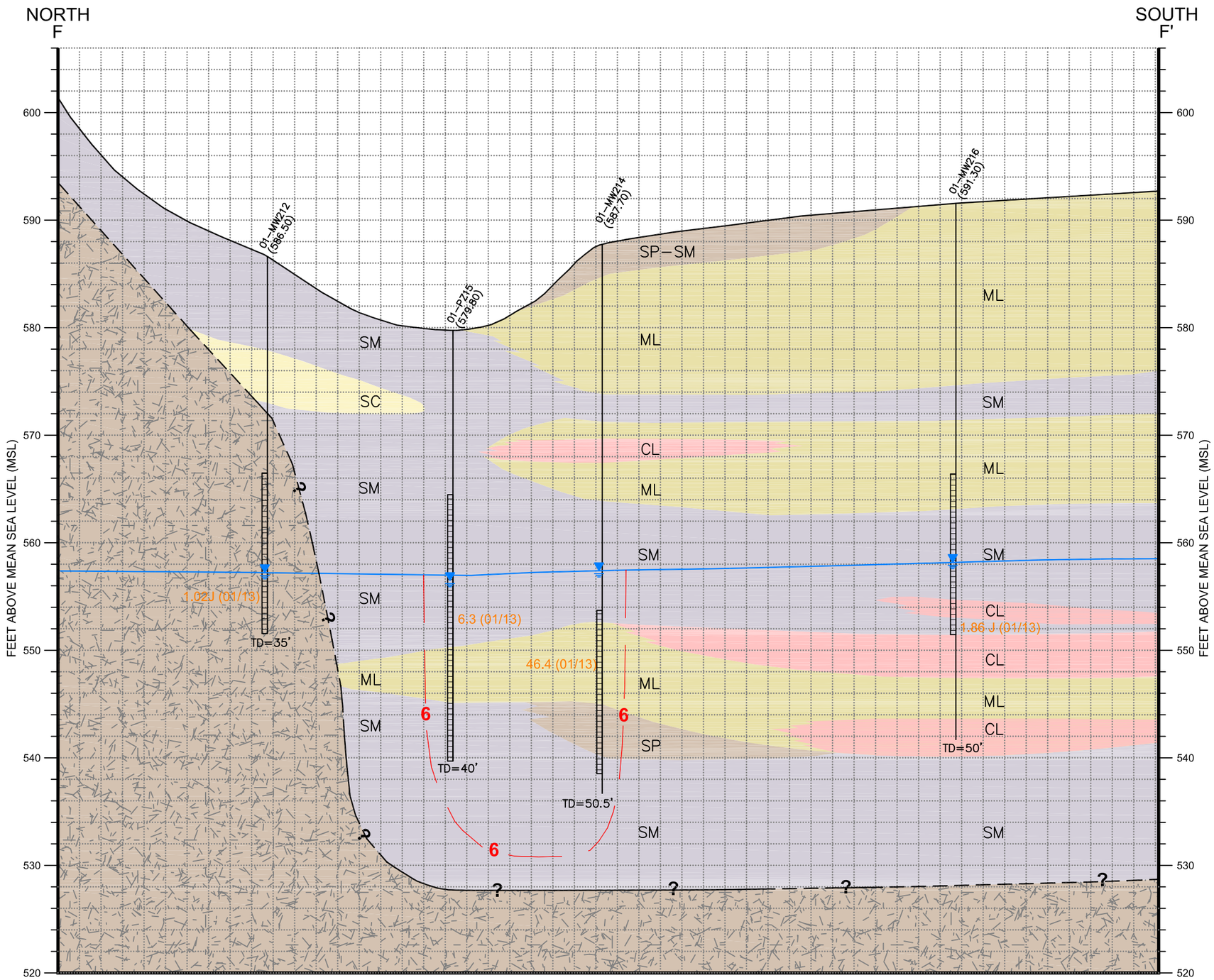
Groundwater RD/RA Work Plan — Final

Hydrogeologic Cross-Sections Within IRP Site 1 Boundary

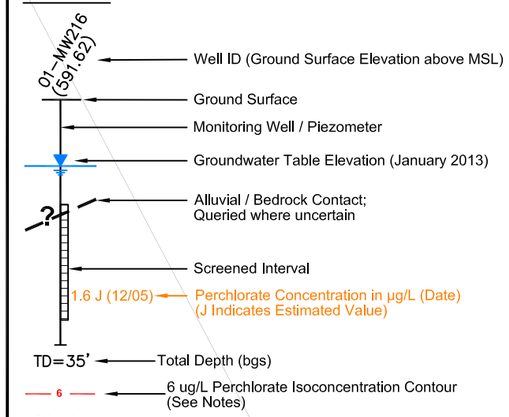
IRP Sites 1 & 2

Date: 12-13	Former MCAS El Toro	Figure
Project No. 60225245	AECOM-ENVIROCON JOINT VENTURE	3-5

File: P:\60225245 - FERMAC & El Toro Sites 1 and 2 GWTP\Deliverables\1.2 CAD\RD\RA Work Plan\Rev0\FIGURE 3-5.dwg Layout: Figure 3-5 User: certlbj1 Plotted: Dec 09, 2015 - 1:24pm



LEGEND



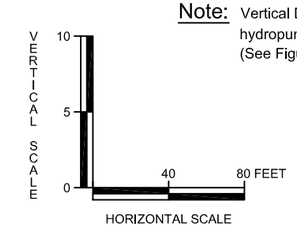
Lithology

- CL - Clay, Sandy Clay, Silty Clay
- ML - Silt, Silt with Sand
- SC - Clayey Sand
- SM - Silty Sand
- SP - Poorly Graded Sand
- Weathered Bedrock - Sandstone, Claystone

Explanation

'	Feet
bgs	Below Ground Surface
EOD	Explosive Ordnance Disposal
ID	Identification
IRP	Installation Restoration Program
MCAS	Marine Corps Air Station
MSL	Mean Sea Level
TD	Total Depth

Note: Vertical Delineation based on the results of hydropunch samples collected at 01-HPB1 (See Figure 3-1)



Groundwater RD/RA Work Plan — Final

Hydrogeologic Cross Section E-E' Intermediate Area

IRP Sites 1 & 2

Date: 12-13	Former MCAS El Toro	Figure
Project No. 60225245	AECOM-ENVIROCON JOINT VENTURE	3-6

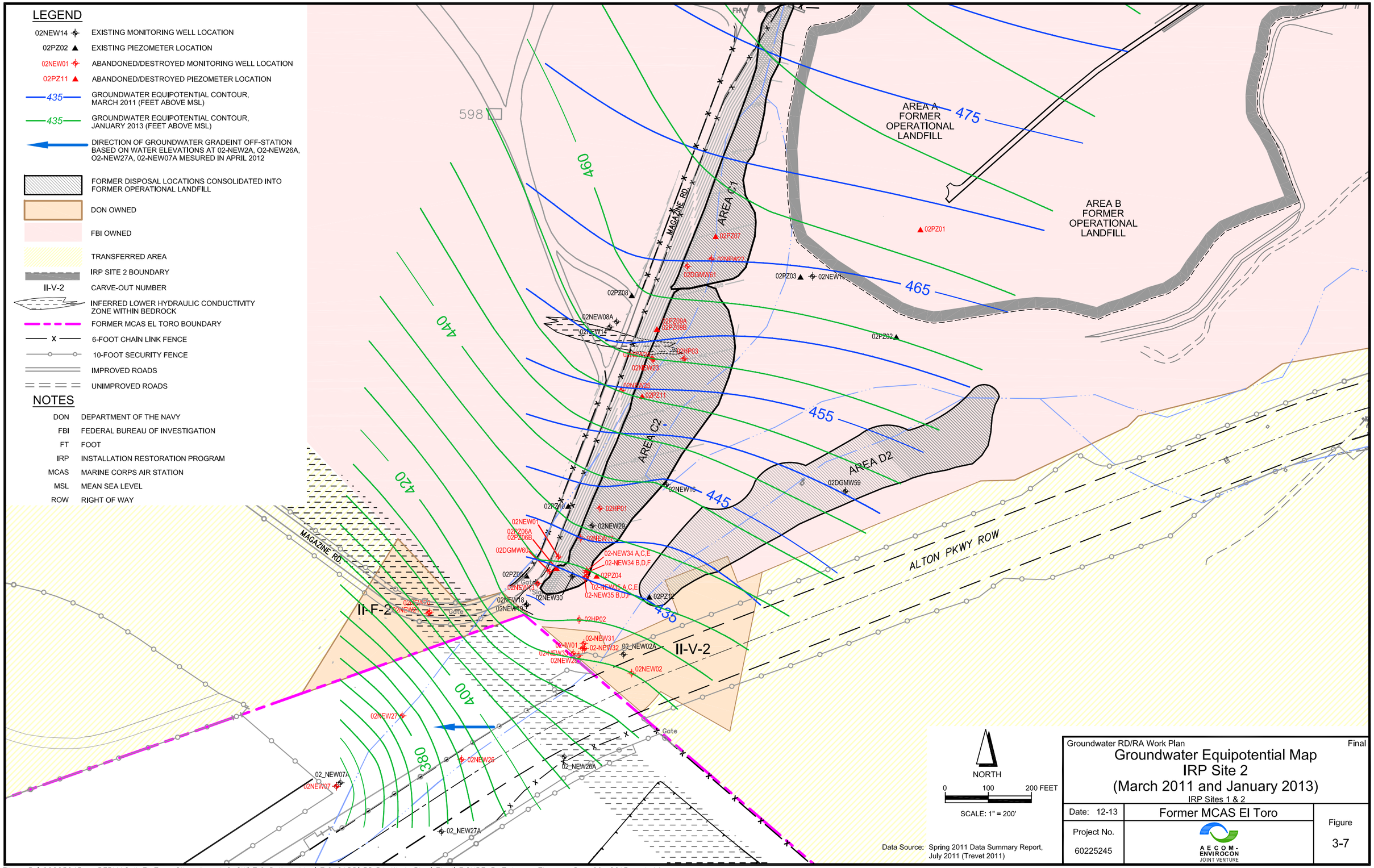
File: P:\60225245 – PERMAC II El Toro Sites 1 and 2 GW\7.0 Deliverables\7.2 CADD\RD.RA Work Plan\Final\FIGURE 3-6.dwg Time: Dec 04, 2013 – 3:07pm

LEGEND

- 02NEW14 — EXISTING MONITORING WELL LOCATION
- 02PZ02 — EXISTING PIEZOMETER LOCATION
- 02NEW01 — ABANDONED/DESTROYED MONITORING WELL LOCATION
- 02PZ11 — ABANDONED/DESTROYED PIEZOMETER LOCATION
- 435 — GROUNDWATER EQUIPOTENTIAL CONTOUR, MARCH 2011 (FEET ABOVE MSL)
- 435 — GROUNDWATER EQUIPOTENTIAL CONTOUR, JANUARY 2013 (FEET ABOVE MSL)
- DIRECTION OF GROUNDWATER GRADEINT OFF-STATION BASED ON WATER ELEVATIONS AT 02-NEW2A, O2-NEW26A, O2-NEW27A, 02-NEW07A MESURED IN APRIL 2012
- FORMER DISPOSAL LOCATIONS CONSOLIDATED INTO FORMER OPERATIONAL LANDFILL
- DON OWNED
- FBI OWNED
- TRANSFERRED AREA
- IRP SITE 2 BOUNDARY
- II-V-2 — CARVE-OUT NUMBER
- INFERRED LOWER HYDRAULIC CONDUCTIVITY ZONE WITHIN BEDROCK
- FORMER MCAS EL TORO BOUNDARY
- 6-FOOT CHAIN LINK FENCE
- 10-FOOT SECURITY FENCE
- IMPROVED ROADS
- UNIMPROVED ROADS

NOTES

DON	DEPARTMENT OF THE NAVY
FBI	FEDERAL BUREAU OF INVESTIGATION
FT	FOOT
IRP	INSTALLATION RESTORATION PROGRAM
MCAS	MARINE CORPS AIR STATION
MSL	MEAN SEA LEVEL
ROW	RIGHT OF WAY



Data Source: Spring 2011 Data Summary Report, July 2011 (Trevet 2011)

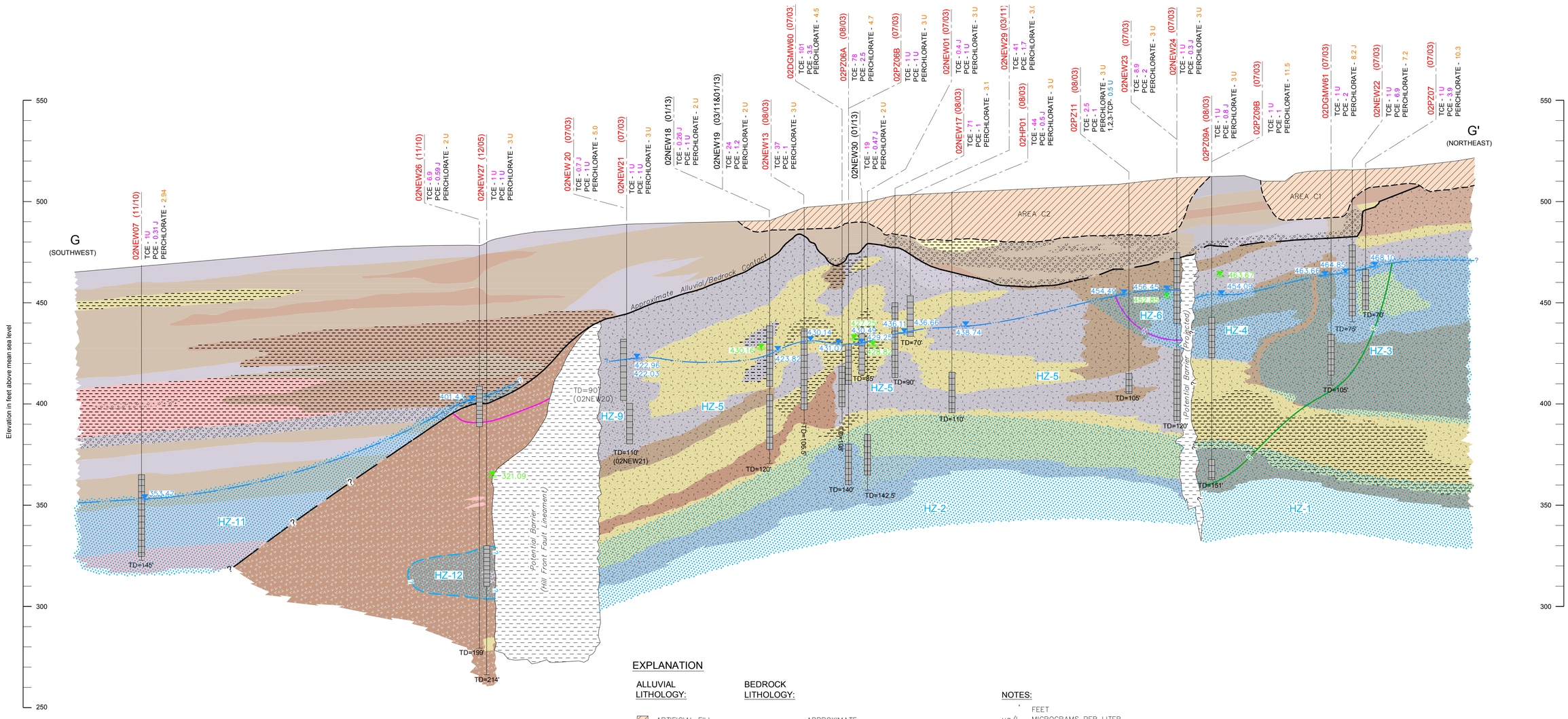
Groundwater RD/RA Work Plan — Final

Groundwater Equipotential Map IRP Site 2 (March 2011 and January 2013)

IRP Sites 1 & 2

Date: 12-13	Former MCAS El Toro	Figure
Project No. 60225245	AECOM-ENVIROCON JOINT VENTURE	3-7

File: P:\60225245 – PERMAC II El Toro Sites 1 and 2 GW\7.0 Deliverables\7.2 CADD\RD.RA Work Plan\Final\FIGURE 3–7.dwg Time: Dec 09, 2013 – 1:44pm



EXPLANATION

ALLUVIAL LITHOLOGY:

- ARTIFICIAL FILL
- CLAY
- CL/ML
- GRAVEL
- ML
- SILT
- SC
- SM
- SP
- SW

BEDROCK LITHOLOGY:

- APPROXIMATE ALLUVIAL / BEDROCK CONTACT (DASHED WHERE INFERRED)
- ML (SILTSTONE)
- SM, SP, SW (SANDSTONE)
- BRECCIA
- POTENTIAL BARRIER
- HZ-2 HYDROGEOLOGIC ZONE

NOTES:

'	FEET
µg/L	MICROGRAMS PER LITER
DON	DEPARTMENT OF THE NAVY
FBI	FEDERAL BUREAU OF INVESTIGATION
IRP	IRP
ND	NON DETECT
MCAS	MARINE CORPS AIR STATION
PCE	TETRACHLOROETHENE
TCE	TRICHLOROETHENE
TCP	TRICHLORO PROPANE
TD	TOTAL DEPTH

- GROUNDWATER ELEVATION/POTENTIOMETRIC SURFACE (MEASURED NOVEMBER 2010)
- GROUNDWATER ELEVATION/POTENTIOMETRIC SURFACE OF WELL IN PIEZOMETER NOT USED IN GROUNDWATER ELEVATION/POTENTIOMETRIC SURFACE MAP
- INFERRED GROUNDWATER ELEVATION/POTENTIOMETRIC SURFACE (MEASURED NOVEMBER 2010)
- 5 TCE ISO CONCENTRATION CONTOUR (5 µg/L)
- 6 PERCHLORATE ISO CONCENTRATION CONTOUR (6 µg/L)

02NEW26 (11/10) — TCE - 6.9, PCE - 0.89 J, PERCHLORATE - 2 U: MONITORING WELL LABEL (SHOWING WATER QUALITY RESULTS FROM DATE INDICATED)

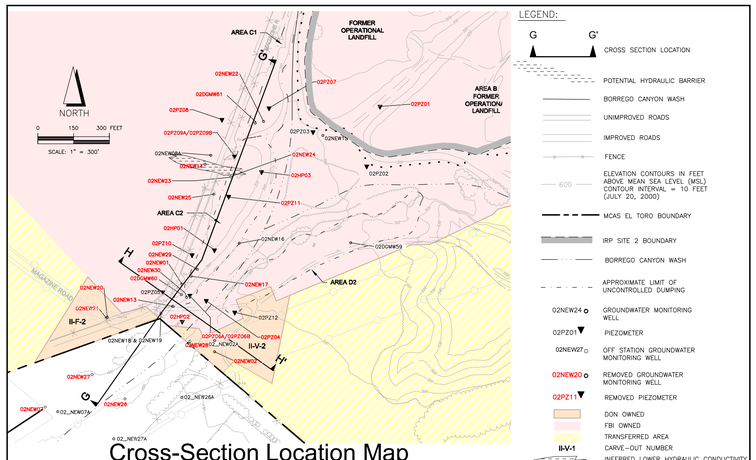
TD=199': SCREENED INTERVAL OF MONITORING WELL; TOTAL DEPTH OF WELL BORING IN FEET BELOW GROUND SURFACE

J: ESTIMATED
U: NON DETECT
(P): WELL PROJECTED

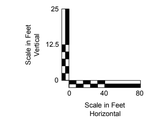
02NEW20 (07/03) — TCE - 0.7 J, PCE - 1 U, PERCHLORATE - 5.0: REMOVED MONITORING WELL LABEL (SHOWING WATER QUALITY RESULTS FROM DATE INDICATED)

TD=80': SCREENED INTERVAL OF MONITORING WELL; TOTAL DEPTH OF WELL BORING IN FEET BELOW GROUND SURFACE

J: ESTIMATED
U: NON DETECT
(P): WELL PROJECTED



Cross-Section Location Map



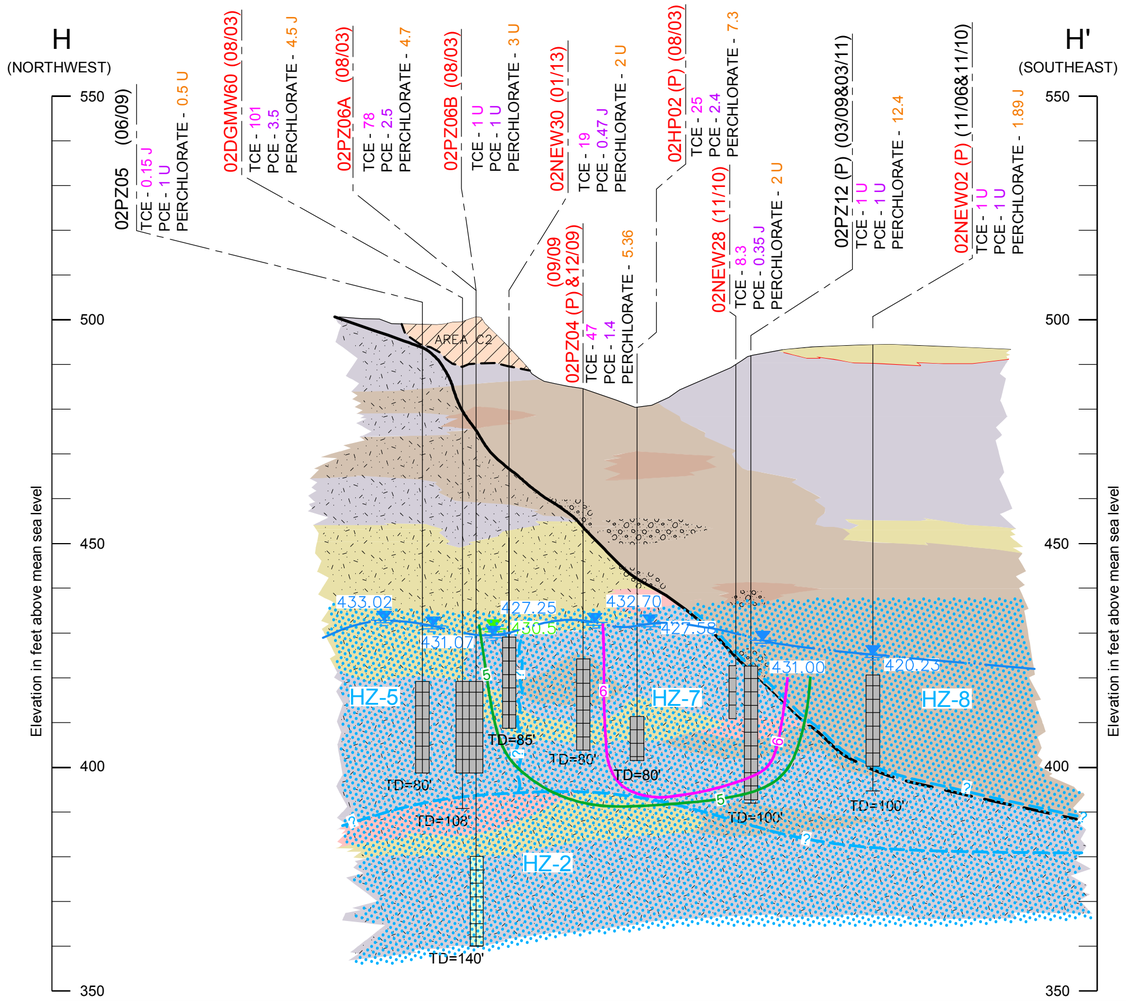
Groundwater RD/RA Work Plan — Final

Hydrogeologic Cross-Section G-G' IRP Site 2

IRP Sites 1 & 2

Date: 12-13	Former MCAS El Toro	Figure
Project No. 60225245	AECOM-ENVIROCON JOINT VENTURE	3-8

File: L:\work\37380\work\Site 2 & 17\CAD\Figures\Site 2 FS Addendum\Final FSA\SITE 2 FSA-CROSS-SECTION A-A_WITH HYDROGEOLOGY.dwg Time: Mar 14, 2007 - 9:58am



EXPLANATION

ALLUVIAL LITHOLOGY:

- ARTIFICIAL FILL
- CLAY
- CL/ML
- GRAVEL
- ML
- SILT
- SC
- SM
- SP
- SW

BEDROCK LITHOLOGY:

- APPROXIMATE ALLUVIAL / BEDROCK CONTACT (DASHED WHERE INFERRED)
- ML (SILTSTONE)
- SM, SP, SW (SANDSTONE)
- POTENTIAL BARRIER
- HZ-2 HYDROGEOLOGIC ZONE
- GROUNDWATER ELEVATION/POTENTIOMETRIC SURFACE (NOVEMBER 2010)
- GROUNDWATER ELEVATION/POTENTIOMETRIC SURFACE OF WELL IN PIEZOMETER NOT USED IN GROUNDWATER ELEVATION/POTENTIOMETRIC SURFACE MAP
- INFERRED GROUNDWATER ELEVATION/POTENTIOMETRIC SURFACE (NOVEMBER 2010)
- 5 TCE ISO CONCENTRATION CONTOUR (5 µg/L)
- 6 PERCHLORATE ISO CONCENTRATION CONTOUR (6 µg/L)

NOTES:

'	FEET
µg/L	MICROGRAMS PER LITER
DON	DEPARMENT OF THE NAVY
FBI	FEDERAL BUREAU OF INVESTIGATION
IRP	IRP
MCAS	MARINE CORPS AIR STATION
PCE	TETRACHLOROETHENE
TCE	TRICHLOROETHENE
TCP	TRICHLORO PROPANE
TD	TOTAL DEPTH

Scale in Feet Vertical: 25, 12.5, 0
Scale in Feet Horizontal: 0, 40, 80

02PZ05 (06/09)
TCE - 1 U
PCE - 1 U
PERCHLORATE - 3 U

MONITORING WELL LABEL (SHOWING WATER QUALITY RESULTS FROM DATE INDICATED)

SCREENED INTERVAL OF MONITORING WELL

TD=80' — TOTAL DEPTH OF WELL BORING IN FEET BELOW GROUND SURFACE

J — ESTIMATED
U — NON DETECT
(P) — WELL PROJECTED

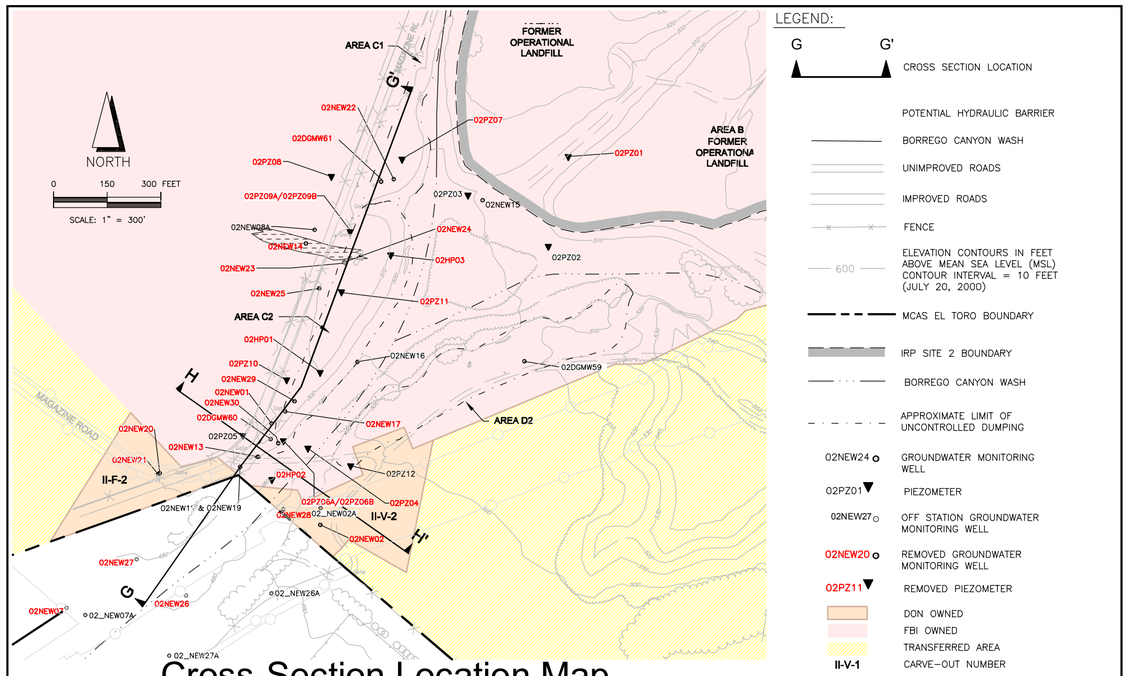
02PZ06A
TCE - 78
PCE - 2.5
PERCHLORATE - 4.7

REMOVED MONITORING WELL LABEL (SHOWING WATER QUALITY RESULTS FROM DATE INDICATED)

SCREENED INTERVAL OF MONITORING WELL

TD=80' — TOTAL DEPTH OF WELL BORING IN FEET BELOW GROUND SURFACE

J — ESTIMATED
U — NON DETECT
(P) — WELL PROJECTED



Cross-Section Location Map

Groundwater RD/RA Work Plan — Final

Hydrologic Cross-Section H-H'
IRP Site 2

IRP Sites 1 & 2

Date: 12-13

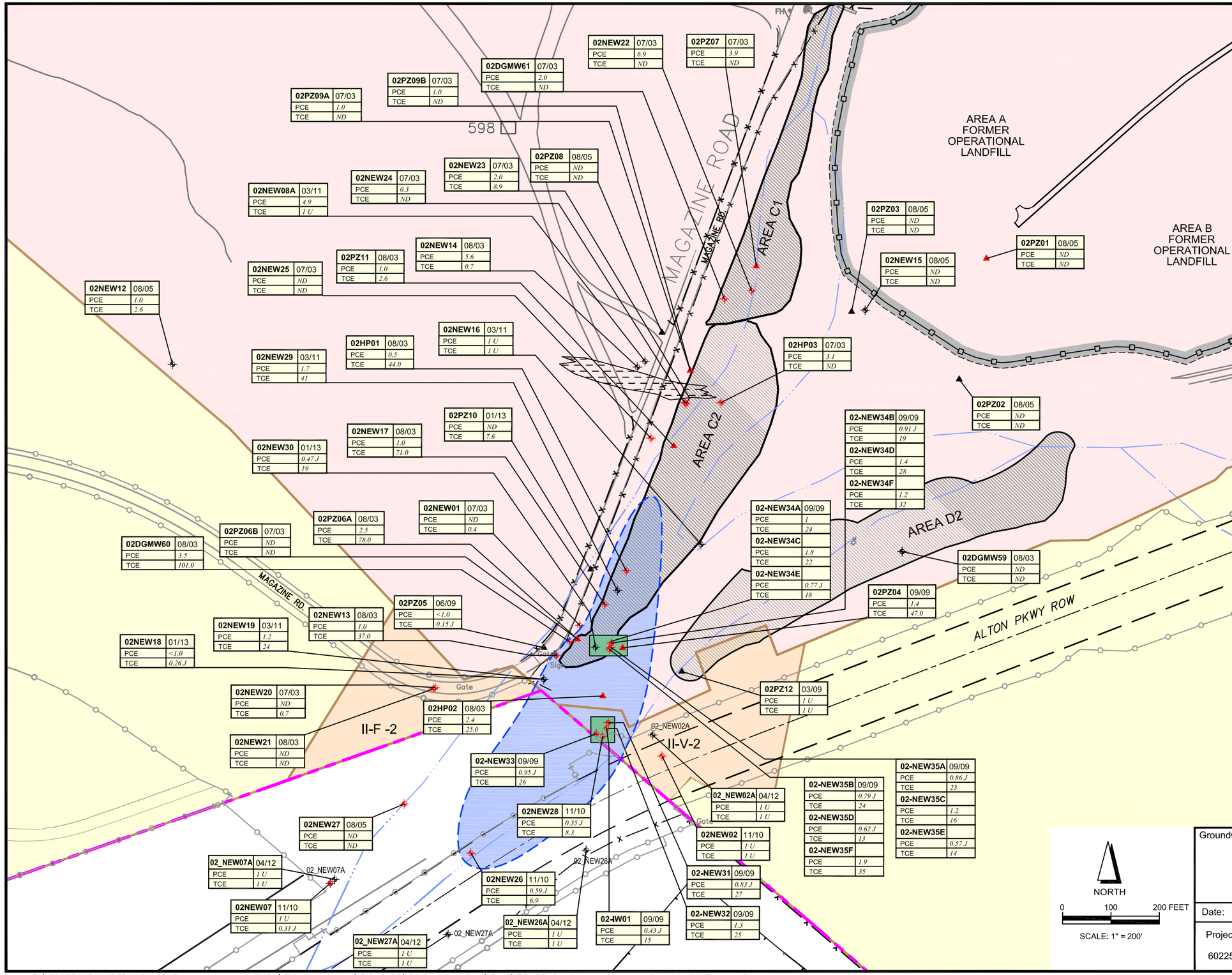
Former MCAS El Toro

Project No. 60225245

AECOM-ENVIROCON JOINT VENTURE

FIGURE 3-9

File: P:\60225245 – PERMAC II El Toro Sites 1 and 2 GW\7.0 Deliverables\7.2 CADD\RD.RA Work Plan\Final\FIGURE 3-9.dwg Time: Dec 05, 2013 – 7:34am



LEGEND

- EXISTING MONITORING WELL LOCATION
- EXISTING PIEZOMETER LOCATION
- ABANDONED/DESTROYED MONITORING WELL LOCATION
- ABANDONED/DESTROYED PIEZOMETER LOCATION
- FORMER DISPOSAL LOCATIONS CONSOLIDATED INTO FORMER OPERATIONAL LANDFILL
- DON OWNED
- FBI OWNED
- TRANSFERRED AREA
- II-V-2 CARVE-OUT NUMBER
- FORMER MCAS EL TORO BOUNDARY
- 3-STRAND WIRE FENCE
- 6-FOOT CHAIN LINK FENCE
- 10-FOOT SECURITY FENCE
- IMPROVED ROADS
- UNIMPROVED ROADS
- TCE ABOVE 5 µg/L (DASHED WHERE INFERRED)
- 2009-2010 ISB PILOT STUDY LOCATIONS
- INFERRED LOWER HYDRAULIC CONDUCTIVITY ZONE WITHIN BEDROCK
- IRP SITE 2 BOUNDARY

NOTES

1. DATA SOURCE: THE ANALYTE CONCENTRATION REPORTED FOR EACH MONITORING LOCATION REPRESENTS THE CONCENTRATION REPORTED DURING THE MOST RECENT OF THE FOLLOWING GROUNDWATER MONITORING EVENTS: AUGUST 2005, JUNE 2009 (PRE-BASELINE AND BASELINE SAMPLING CONDUCTED PRIOR TO PILOT STUDY [AECOM and ECS 2010]), MARCH 2009 GROUNDWATER MONITORING (TREVET 2010), JANUARY 2013 SUPPLEMENTAL GROUNDWATER MONITORING.

< LESS THAN
µg/L MICROGRAMS PER LITER
DON DEPARTMENT OF NAVY
FBI FEDERAL BUREAU OF INVESTIGATION
FT FOOT
ID IDENTIFICATION
IRP INSTALLATION RESTORATION PROGRAM
ISB IN SITU BIOREMEDIATION
MCAS MARINE CORPS AIR STATION
ND NOT DETECTED
PCE TETRACHLOROETHENE
ROW RIGHT OF WAY
TCE TRICHLOROETHENE
TCP TRICHLOROPROPANE

LABORATORY QUALIFIERS

J DATA VALIDATION QUALIFIER INDICATING THAT THE LEVEL STATED IS AN ESTIMATED VALUE.
U DATA VALIDATION QUALIFIER INDICATING THAT THE ANALYTE WAS NOT DETECTED ABOVE THE LEVEL OF THE ASSOCIATED VALUE.

SAMPLE ID	DATE OF SAMPLE (MONTH/YEAR)
ANALYTE	VALUE DETECTED IN µg/L (SEE NOTE #1)

Groundwater RD/RA Work Plan — Final

Estimated Extent of PCE and TCE in Groundwater

IRP Sites 1 & 2

Date: 12-13

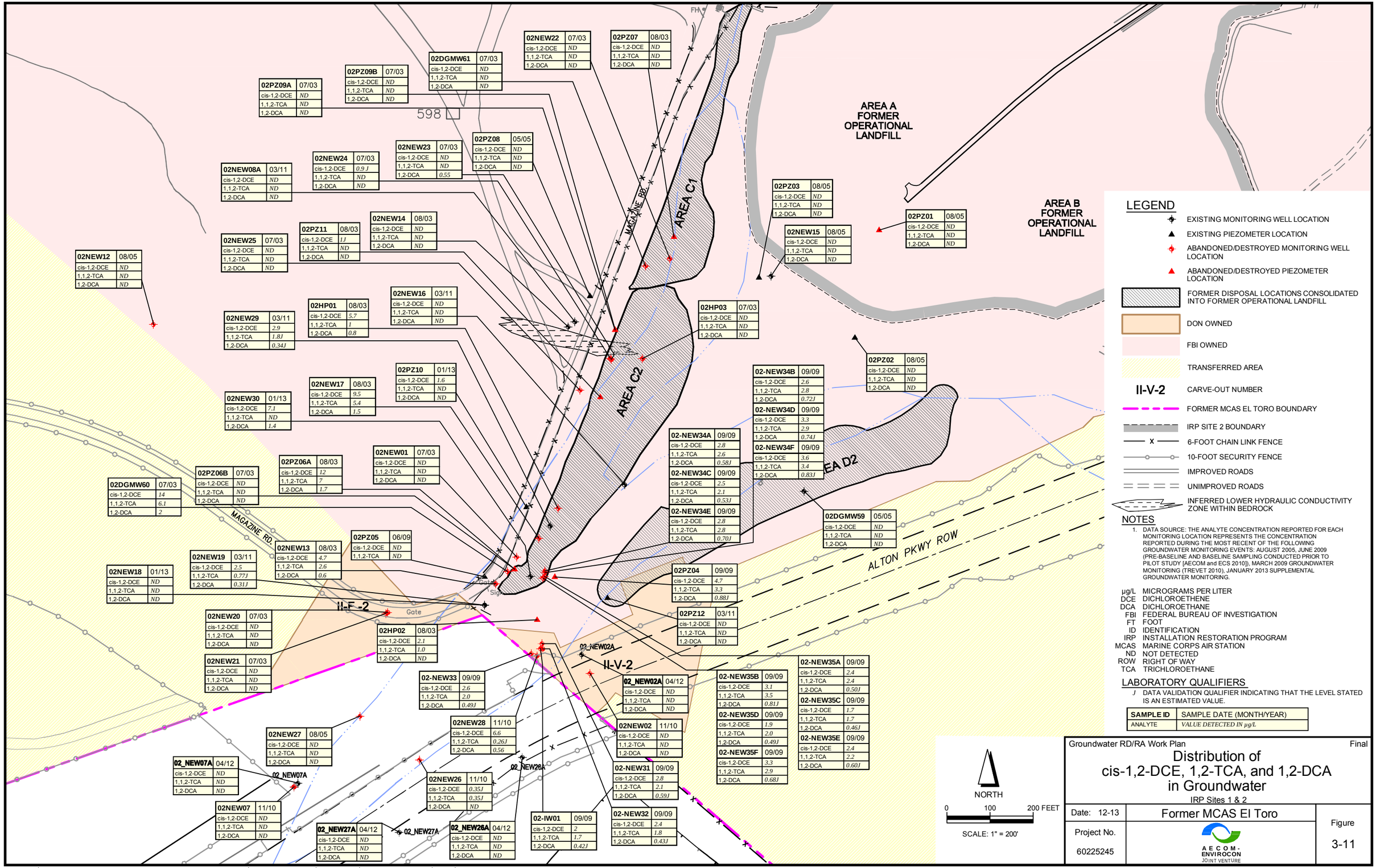
Former MCAS El Toro

Project No. 60225245

AECOM-ENVIROCON JOINT VENTURE

Figure 3-10

File: P:\60225245 – PERMAC II El Toro Sites 1 and 2 GW\7.0 Deliverables\7.2 CADD\RD.RA Work Plan\Final\FIGURE 3–10.dwg Time: Dec 09, 2013 – 1:47pm



LEGEND

- EXISTING MONITORING WELL LOCATION
- EXISTING PIEZOMETER LOCATION
- ABANDONED/DESTROYED MONITORING WELL LOCATION
- ABANDONED/DESTROYED PIEZOMETER LOCATION
- FORMER DISPOSAL LOCATIONS CONSOLIDATED INTO FORMER OPERATIONAL LANDFILL
- DON OWNED
- FBI OWNED
- TRANSFERRED AREA
- II-V-2 CARVE-OUT NUMBER
- FORMER MCAS EL TORO BOUNDARY
- IRP SITE 2 BOUNDARY
- 6-FOOT CHAIN LINK FENCE
- 10-FOOT SECURITY FENCE
- IMPROVED ROADS
- UNIMPROVED ROADS
- INFERRED LOWER HYDRAULIC CONDUCTIVITY ZONE WITHIN BEDROCK

NOTES

1. DATA SOURCE: THE ANALYTE CONCENTRATION REPORTED FOR EACH MONITORING LOCATION REPRESENTS THE CONCENTRATION REPORTED DURING THE MOST RECENT OF THE FOLLOWING GROUNDWATER MONITORING EVENTS: AUGUST 2005, JUNE 2009 (PRE-BASELINE AND BASELINE SAMPLING CONDUCTED PRIOR TO PILOT STUDY [AECOM and ECS 2010]), MARCH 2009 GROUNDWATER MONITORING (TREVET 2010), JANUARY 2013 SUPPLEMENTAL GROUNDWATER MONITORING.

µg/L	MICROGRAMS PER LITER
DCE	DICHLOROETHENE
DCA	DICHLOROETHANE
FBI	FEDERAL BUREAU OF INVESTIGATION
FT	FOOT
ID	IDENTIFICATION
IRP	INSTALLATION RESTORATION PROGRAM
MCAS	MARINE CORPS AIR STATION
ND	NOT DETECTED
ROW	RIGHT OF WAY
TCA	TRICHLOROETHANE

LABORATORY QUALIFIERS

J DATA VALIDATION QUALIFIER INDICATING THAT THE LEVEL STATED IS AN ESTIMATED VALUE.

SAMPLE ID	SAMPLE DATE (MONTH/YEAR)
ANALYTE	*VALUE DETECTED IN µg/L*

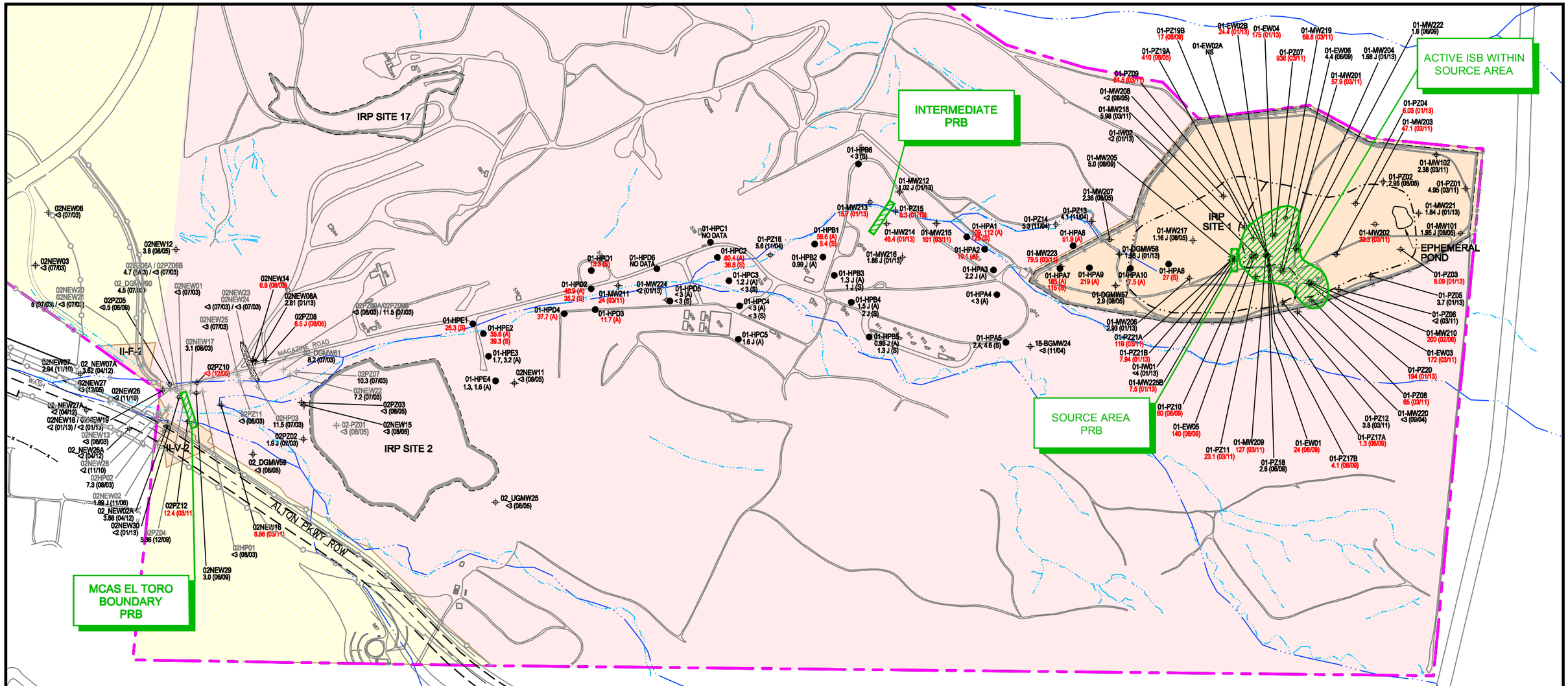
Groundwater RD/RA Work Plan — Final

Distribution of cis-1,2-DCE, 1,2-TCA, and 1,2-DCA in Groundwater

IRP Sites 1 & 2

Date: 12-13	Former MCAS El Toro	Figure
Project No. 60225245	AECOM-ENVIROCON JOINT VENTURE	3-11

File: P:\60225245 – PERMAC II El Toro Sites 1 and 2 GW\7.0 Deliverables\7.2 CADD\RD.RA Work Plan\Final\FIGURE 3–11.dwg Time: Dec 05, 2013 – 9:07am



LEGEND:

01-HPE4 ●	HYDROPUNCH SAMPLING LOCATION
1.6 J (A) / < 3 (S) / J	HYDROPUNCH PERCHLORATE CONCENTRATION IN µg/L, RED INDICATES GREATER THAN 6 µg/L (A INDICATES ALLUVIUM SAMPLE, S INDICATES WEATHERED BEDROCK SAMPLE, J INDICATES ESTIMATED VALUE)
01-MW201	EXISTING 4-INCH GROUNDWATER MONITORING WELL (OR 2-INCH PIEZOMETER), PERCHLORATE CONCENTRATION IN µg/L, RED INDICATES GREATER THAN 6 µg/L
02-NEW01	ABANDONED/DESTROYED 4-INCH GROUNDWATER MONITORING WELL (OR 2-INCH PIEZOMETER), PERCHLORATE CONCENTRATION IN µg/L, RED INDICATES GREATER THAN 6 µg/L
	MCAS EL TORO BOUNDARY
	EOD RANGE BOUNDARY
	IRP SITE BOUNDARY (1, 2, AND 17)
	EPHEMERAL STREAM OR WASH (INTERPOLATED FROM TOPOGRAPHIC DATA)
	6-FOOT CHAIN-LINK FENCE
	10-FOOT SECURITY FENCE
	DON OWNED
	FBI OWNED
	TRANSFERRED AREA
II-V-2	CARVE-OUT NUMBER

NOTES:

1. FOR EACH WELL/SAMPLING LOCATION, THE LATEST AVAILABLE PERCHLORATE CONCENTRATION DATA IS REPORTED BASED ON THE FOLLOWING REPORTS: SPRING 2011 SUMMARY REPORT, IRP SITES 1 AND 2 (TREVET 2011); TECHNICAL MEMORANDUM, IN-SITU BIOREMEDIATION PILOT STUDY, IRP SITE 1 (AECOM AND ECS 2011); AND FINAL GROUNDWATER FEASIBILITY STUDY, IRP SITES 1 AND 2 (AECOM 2011); AND SUPPLEMENTAL GROUNDWATER MONITORING, JANUARY 2013.

<	LESS THAN
µg/L	MICROGRAMS PER LITER
DON	DEPARTMENT OF THE NAVY
EOD	EXPLOSIVE ORDNANCE DISPOSAL
FBI	FEDERAL BUREAU OF INVESTIGATION
IRP	INSTALLATION RESTORATION PROGRAM
MCAS	MARINE CORPS AIR STATION
NS	NOT SAMPLED
RI	REMEDIAL INVESTIGATION
ROW	RIGHT-OF-WAY

NORTH

0 350 700 FEET

SCALE: 1" = 700'

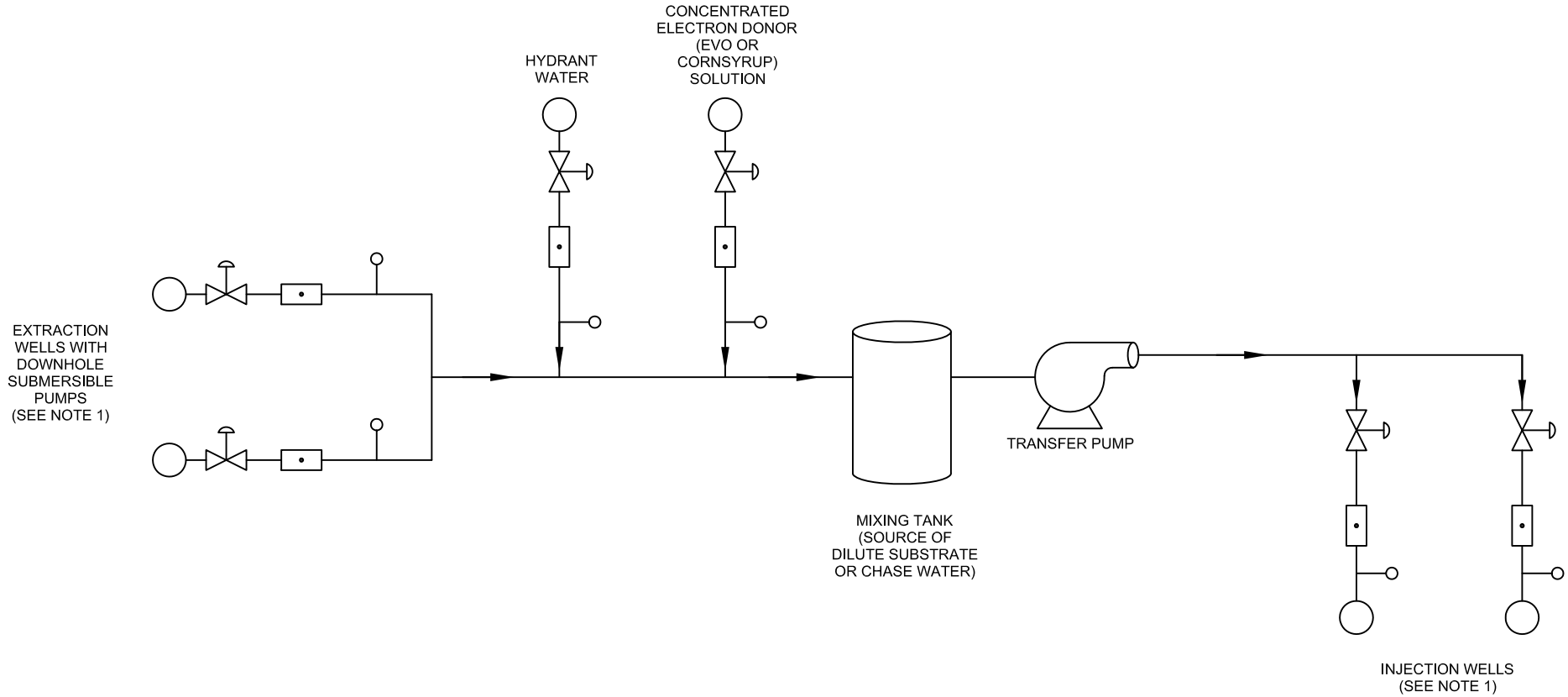
Groundwater RD/RA Work Plan — Final

IRP Site 1 Perchlorate – Impacted Groundwater ISB Locations

IRP Sites 1 & 2

Date: 12-13	Former MCAS El Toro	Figure
Project No. 60225245	AECOM-ENVIROCON JOINT VENTURE	6-1

File: P:\60225245 – PERMAC II El Toro Sites 1 and 2 GW\7.0 Deliverables\7.2 CADD\RD.RA Work Plan\Final\FIGURE 6-1A.dwg Time: Dec 05, 2013 – 9:10am



LEGEND

- FLOW CONTROL VALVE
- FLOW METER
- PRESSURE GAUGE

NOTES

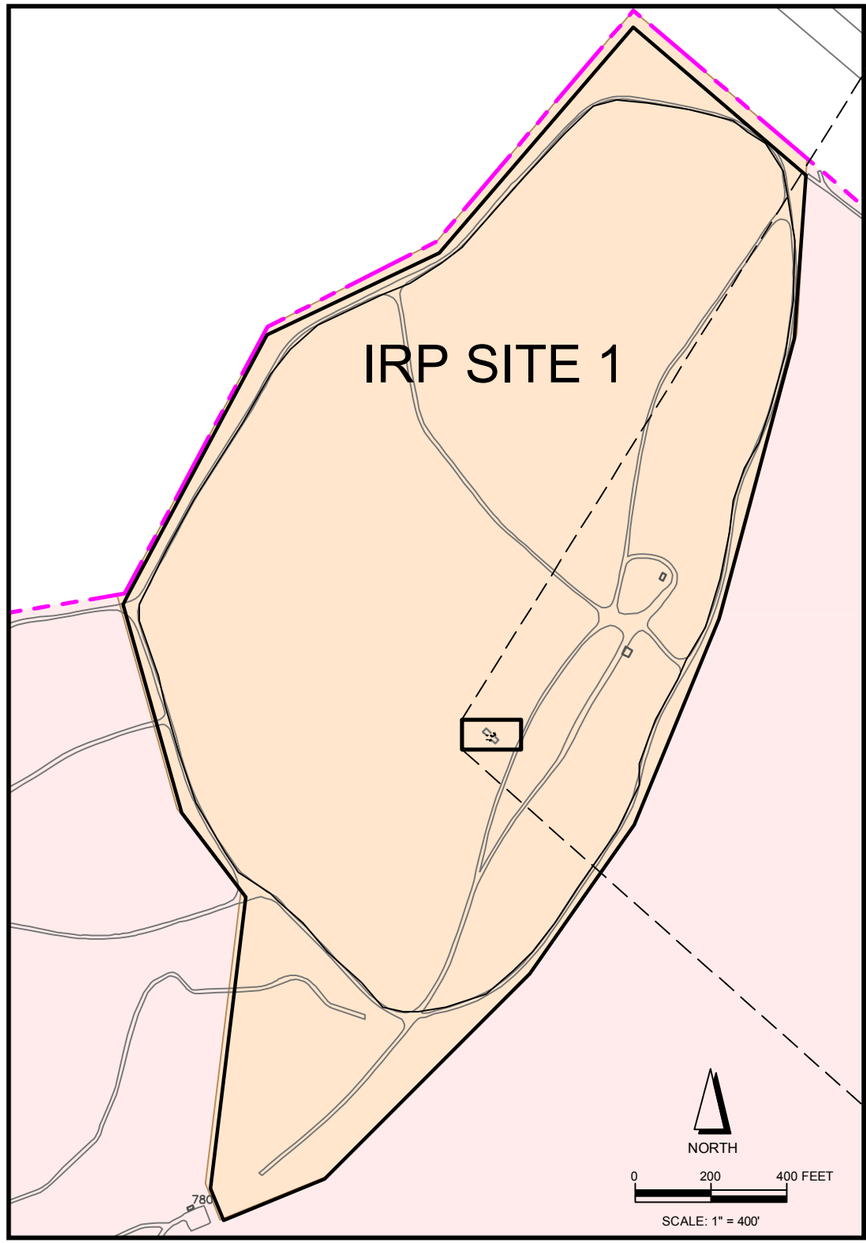
1. APPROPRIATE NUMBER OF EXTRACTION AND INJECTION WELLS TO BE BROUGHT ON-LINE SIMULTANEOUSLY WILL VARY WITH ISB LOCATION AND PRACTICAL CONSIDERATIONS SUCH AS ABILITY TO EFFECTIVELY CONTROL PRESSURES AND FLOW RATES.

Groundwater RD/RA Work Plan — Final

Conceptual Process Flow Diagram for Substrate Injection Into Wells

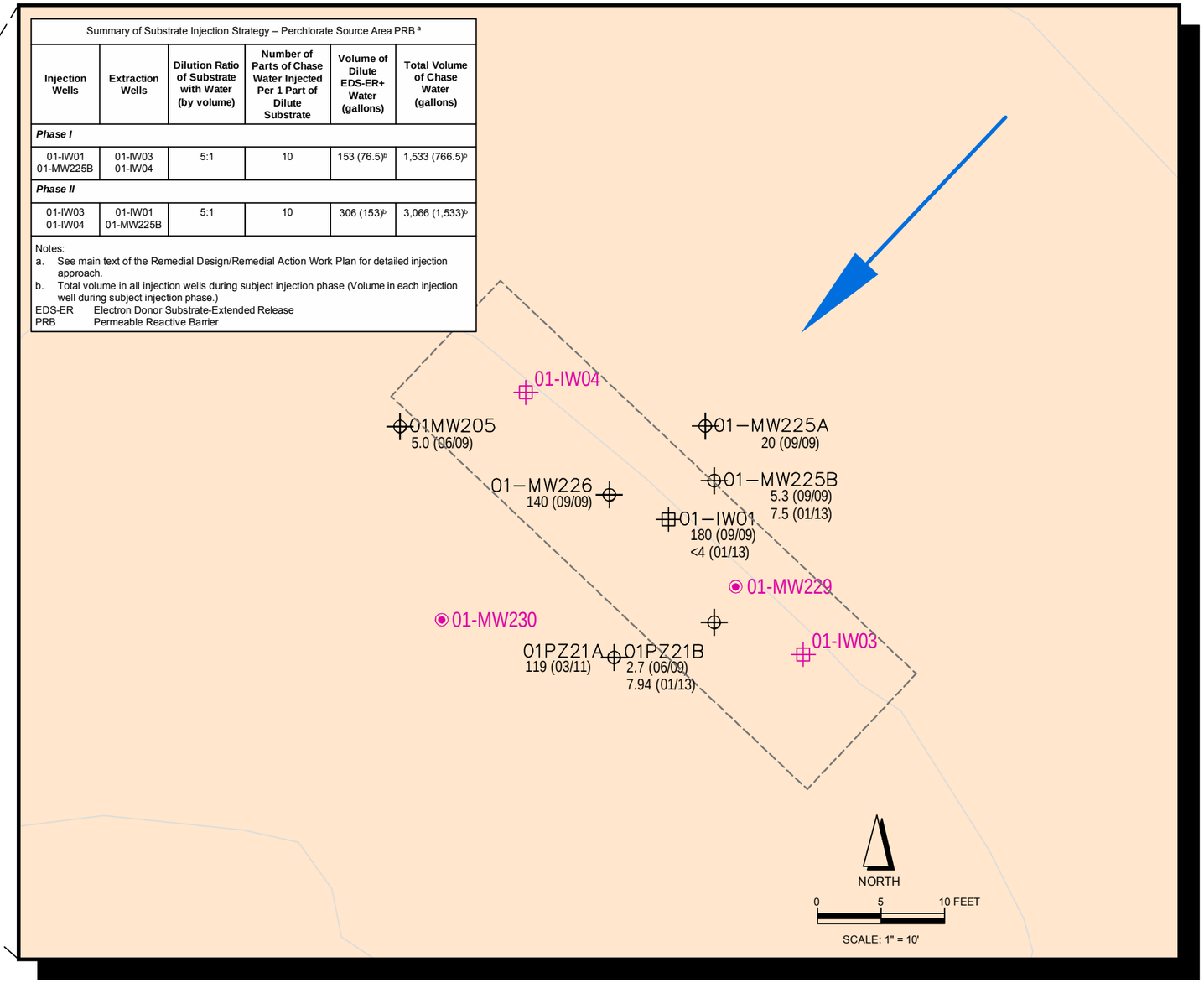
IRP Sites 1 & 2

Date: 12-13	Former MCAS El Toro	Figure
Project No. 60225245	AECOM-ENVIROCON JOINT VENTURE	6-2



Summary of Substrate Injection Strategy – Perchlorate Source Area PRB [a]					
Injection Wells	**Extraction Wells**	**Dilution Ratio of Substrate with Water (by volume)**	**Number of Parts of Chase Water Injected Per 1 Part of Dilute Substrate**	**Volume of Dilute EDS-ER+ Water (gallons)**	**Total Volume of Chase Water (gallons)**
Phase I					
01-IW01 01-MW225B	01-IW03 01-IW04	5:1	10	153 (76.5)[b]	1,533 (766.5)[b]
Phase II					
01-IW03 01-IW04	01-IW01 01-MW225B	5:1	10	306 (153)[b]	3,066 (1,533)[b]

Notes:
a. See main text of the Remedial Design/Remedial Action Work Plan for detailed injection approach.
b. Total volume in all injection wells during subject injection phase (Volume in each injection well during subject injection phase.)
EDS-ER Electron Donor Substrate-Extended Release
PRB Permeable Reactive Barrier



SOURCE AREA PRB DESIGN

LEGEND

- 01-IW03 — PROPOSED INJECTION WELL
- 01-MW229 — PROPOSED MONITORING WELL
- 01–MW204 — EXISTING WELL OR PIEZOMETER (PERCHLORATE CONCENTRATION IS SHOWN IN µg/L) (SEE NOTES 1 AND 2)
- 01–IW01 — EXISTING INJECTION WELL
- GENERAL GROUNDWATER FLOW DIRECTION
- IRP SITE BOUNDARY
- FORMER MCAS EL TORO BOUNDARY
- TARGET IN-SITU REACTION ZONE BASED ON DESIGN ROI'S (SEE NOTE 3)
- DON OWNED
- FBI OWNED

NOTES:

1. FOR THE WELLS FOR WHICH ONE CONCENTRATION VALUE IS REPORTED, THE REPORTED VALUE IS THE LATEST AVAILABLE BASED ON THE FOLLOWING REPORTS/ SAMPLING EVENTS: SPRING 2011 SUMMARY REPORT, IRP SITES 1 AND 2 (TREVET 2011); TECHNICAL MEMORANDUM, IN-SITU BIOREMEDIATION PILOT STUDY, IRP SITE 1 (AECOM AND ECS 2011); FINAL GROUNDWATER FEASIBILITY STUDY, IRP SITES 1 AND 2 (AECOM 2011); AND SUPPLEMENTAL GROUNDWATER MONITORING, JANUARY 2013.
2. FOR THE WELLS FOR WHICH TWO CONCENTRATION VALUES ARE REPORTED, THE FIRST AND SECOND REPORTED VALUES ARE BASED ON THE GROUNDWATER MONITORING EVENTS CONDUCTED PRIOR TO AND AFTER THE COMPLETION OF THE IN-SITU BIOREMEDIATION PILOT STUDY, RESPECTIVELY.
3. DOWNGRADIENT EXTENT OF THE REACTION ZONE IS LIKELY TO EXCEED THE EXTENT SHOWN ON THE FIGURE DUE TO ADVECTION.

µg/L MICROGRAMS PER LITER
DON DEPARTMENT OF THE NAVY
FBI FEDERAL BUREAU OF INVESTIGATION
IRP INSTALLATION RESTORATION PROGRAM
MCAS MARINE CORPS AIR STATION
PRB PERMEABLE REACTIVE BARRIER
ROI RADIUS OF INFLUENCE

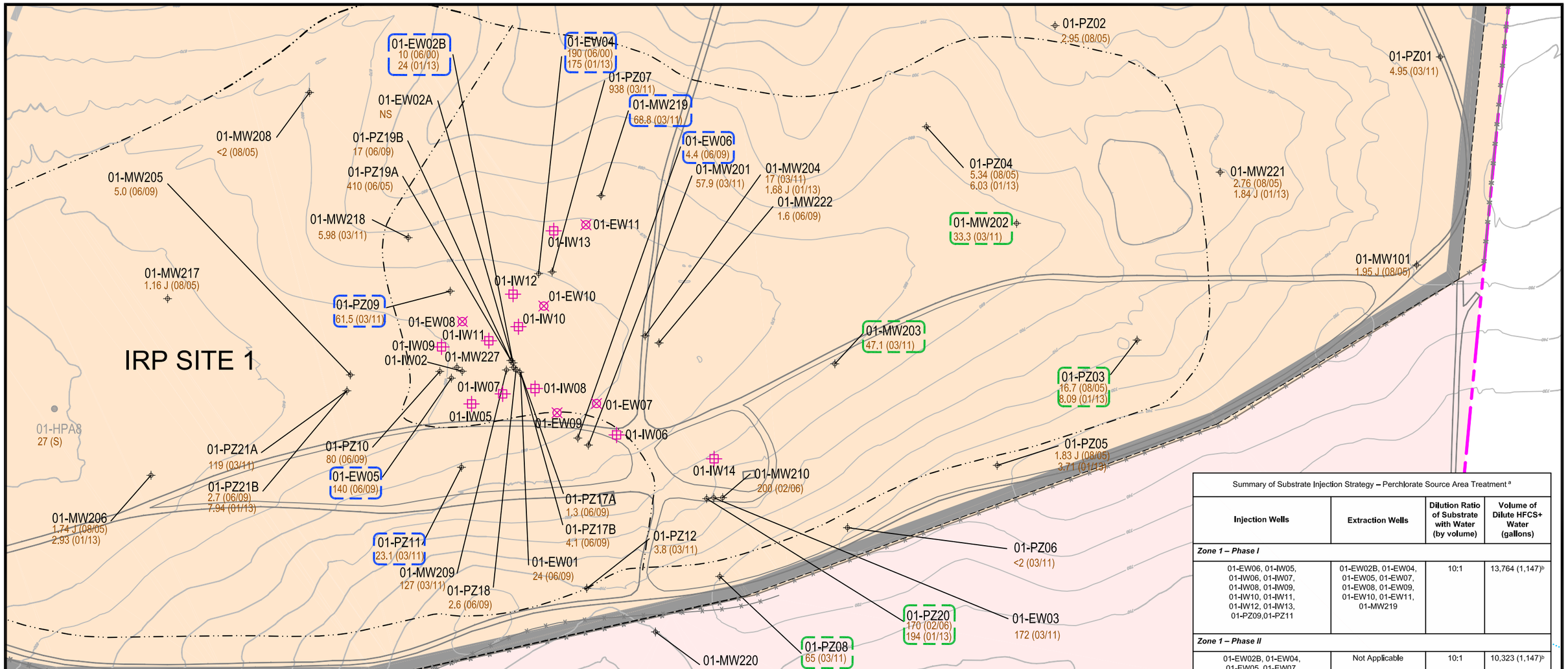
Groundwater RD/RA Work Plan — Final

Source Area PRB Design – IRP Site 1
Perchlorate – Impacted Groundwater

IRP Sites 1 & 2

Date: 12-13	Former MCAS El Toro	Figure
Project No. 60225245	AECOM-ENVIROCON JOINT VENTURE	6-3

File: P:\60225245 – PERMAC II El Toro Sites 1 and 2 GW\7.0 Deliverables\7.2 CADD\RD.RA Work Plan\Final\FIGURE 6–3A.dwg Time: Dec 05, 2013 – 9:14am



Summary of Substrate Injection Strategy – Perchlorate Source Area Treatment [a]			
Injection Wells	**Extraction Wells**	**Dilution Ratio of Substrate with Water (by volume)**	**Volume of Dilute HFCS+ Water (gallons)**
Zone 1 – Phase I			
01-EW06, 01-IW05, 01-IW06, 01-IW07, 01-IW08, 01-IW09, 01-IW10, 01-IW11, 01-IW12, 01-IW13, 01-PZ09,01-PZ11	01-EW02B, 01-EW04, 01-EW05, 01-EW07, 01-EW08, 01-EW09, 01-EW10, 01-EW11, 01-MW219	10:1	13,764 (1,147)[b]
Zone 1 – Phase II			
01-EW02B, 01-EW04, 01-EW05, 01-EW07, 01-EW08, 01-EW09, 01-EW10, 01-EW11, 01-MW219	Not Applicable	10:1	10,323 (1,147)[b]
Zone 2 and Upgradient of Zone 1			
01-PZ20, 01-PZ08, 01-MW203, 01-MW202, 01-PZ03, 01-IW14	Not Applicable	10:1	648 (108)[b]

Notes:
a. See main text of the Remedial Design/Remedial Action Work Plan for detailed injection approach.
b. Total volume in all listed injection wells (Volume in each injection well).
HFCS High Fructose Corn Syrup

LEGEND:

- PROPOSED INJECTION WELL
- PROPOSED EXTRACTION WELL
- 01-HPA8 — HYDROPUNCH SAMPLING LOCATION
- 27 (S) — HYDROPUNCH PERCHLORATE CONCENTRATION S INDICATES WEATHERED BEDROCK SAMPLE,
- 01-MW206 — EXISTING WELL OR PIEZOMETER (PERCHLORATE CONCENTRATION IS SHOWN IN µg/L) (SEE NOTES 1 AND 2)
- MCAS EL TORO BOUNDARY
- EOD RANGE BOUNDARY
- IRP SITE 1 BOUNDARY
- EXISTING FENCE
- EXISTING WELLS WITHIN ZONE 1 TO BE USED FOR HYDRAULICALLY ENHANCED SUBSTRATE INJECTION DURING PHASE I AND PHASE II (SEE TABLE)
- EXISTING WELLS WITHIN ZONE 2 AND UPGRADIENT OF ZONE 1 WHERE SUBSTRATE WILL BE INJECTED WITHOUT HYDRAULIC ENHANCEMENT
- DON OWNED
- FBI OWNED

NOTES:

1. FOR THE WELLS FOR WHICH ONE CONCENTRATION VALUE IS REPORTED, THE REPORTED VALUE IS THE LATEST AVAILABLE BASED ON THE FOLLOWING REPORTS/ SAMPLING EVENTS: SPRING 2011 SUMMARY REPORT, IRP SITES 1 AND 2 (TREVET 2011); TECHNICAL MEMORANDUM, IN-SITU BIOREMEDIATION PILOT STUDY, IRP SITE 1 (AECOM AND ECS 2011); FINAL GROUNDWATER FEASIBILITY STUDY, IRP SITES 1 AND 2 (AECOM 2011); AND SUPPLEMENTAL GROUNDWATER MONITORING, JANUARY 2013.
2. FOR THE WELLS FOR WHICH TWO CONCENTRATION VALUES ARE REPORTED, THE FIRST AND SECOND REPORTED VALUES ARE BASED ON THE GROUNDWATER MONITORING EVENTS CONDUCTED PRIOR TO AND AFTER THE COMPLETION OF THE IN-SITU BIOREMEDIATION PILOT STUDY, RESPECTIVELY.
3. THE DILUTION WATER FOR SUBSTRATE WILL BE AMENDED WITH HYDRANT WATER

< LESS THAN
µg/L MICROGRAMS PER LITER
DON DEPARTMENT OF THE NAVY
EOD EXPLOSIVE ORDNANCE DISPOSAL
FBI FEDERAL BUREAU OF INVESTIGATION
IRP INSTALLATION RESTORATION PROGRAM
MCAS MARINE CORPS AIR STATION
NS NOT SAMPLED

NORTH

0 75 150 FEET
SCALE: 1" = 150'

Groundwater RD/RA Work Plan — Final

Source Area Treatment – IRP Site 1 Perchlorate – Impacted Groundwater

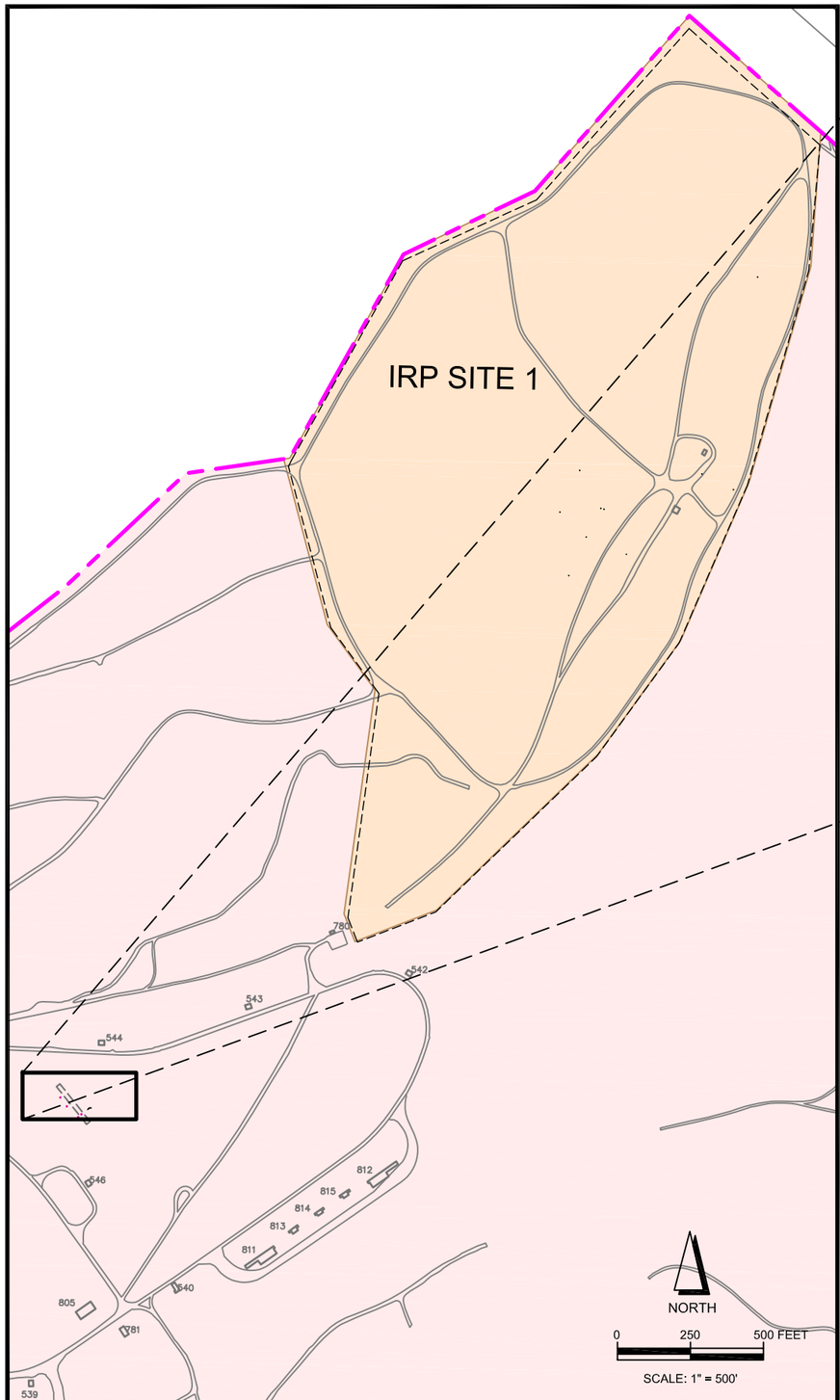
IRP Sites 1 & 2

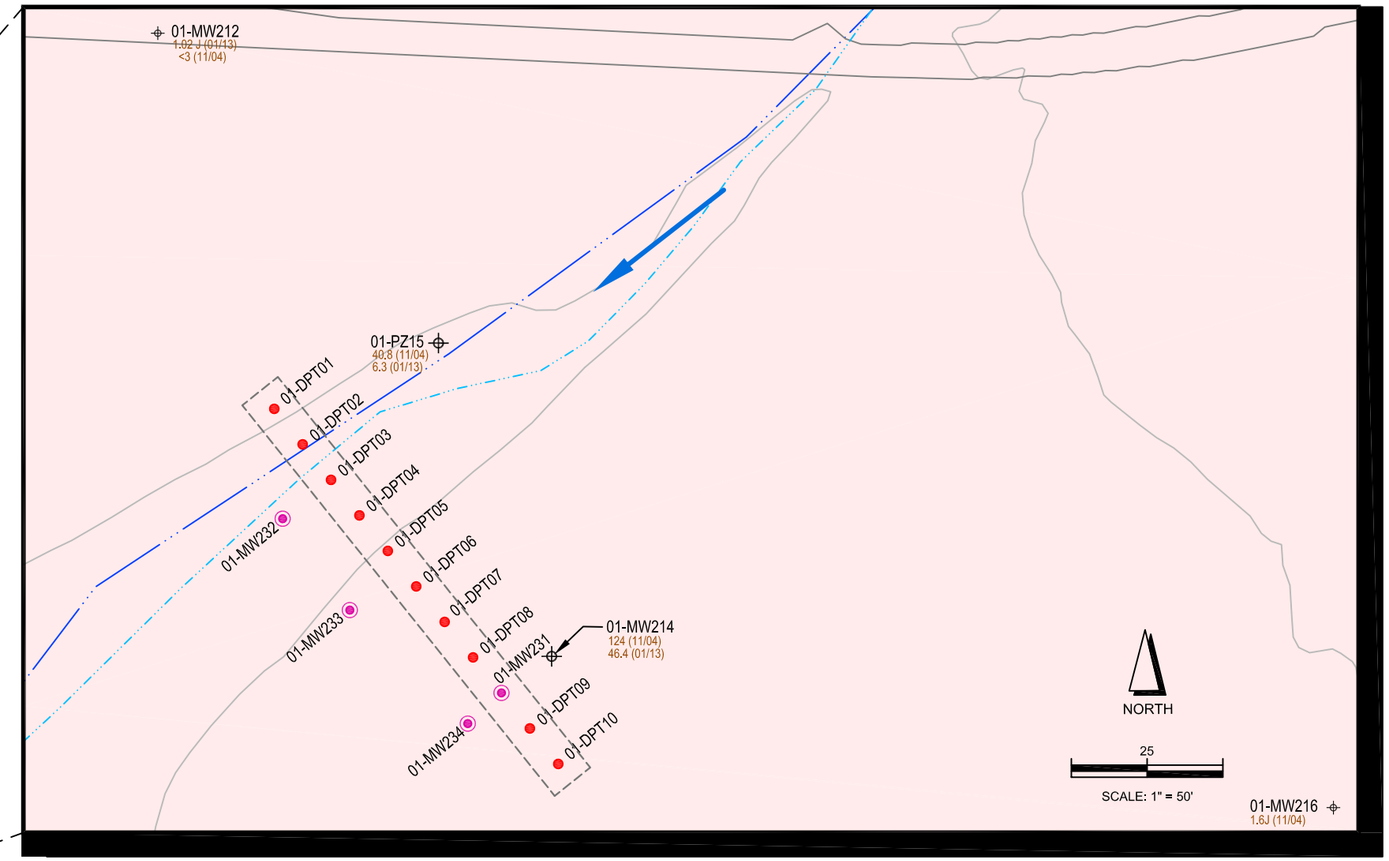
Date: 12-13 | Former MCAS El Toro | Figure 6-4

Project No. 60225245

AECOM-ENVIROCON JOINT VENTURE

File: P:\60225245 – PERMAC II El Toro Sites 1 and 2 GW\7.0 Deliverables\7.2 CADD\RD.RA Work Plan\Final\FIGURE 6-4A.dwg Time: Dec 05, 2013 – 9:16am





INTERMEDIATE AREA PRB DESIGN

LEGEND:

- 01-HPE4 — HYDROPUNCH SAMPLING LOCATION (PERCHLORATE CONCENTRATION IS SHOWN IN µg/L)
- 01-MW233 — PROPOSED INJECTION/ MONITORING WELL
- 01-DPT15 — PROPOSED DIRECT PUSH LOCATION
- 01-MW206 — EXISTING WELL OR PIEZOMETER (PERCHLORATE CONCENTRATION IS SHOWN IN µg/L) (SEE NOTES 1 AND 2)
- EPHEMERAL STREAM OR WASH (INTERPOLATED FROM TOPOGRAPHIC DATA)
- GENERAL GROUNDWATER FLOW DIRECTION
- MCAS EL TORO BOUNDARY
- TARGET IN-SITU REACTION ZONE BASED ON DESIGN ROI'S
- DON OWNED
- FBI OWNED

NOTES:

1. FOR THE WELLS FOR WHICH ONE CONCENTRATION VALUE IS REPORTED, THE REPORTED VALUE IS THE LATEST AVAILABLE BASED ON THE FOLLOWING REPORTS/ SAMPLING EVENTS: SPRING 2011 SUMMARY REPORT, IRP SITES 1 AND 2 (TREVET 2011); TECHNICAL MEMORANDUM, IN-SITU BIOREMEDIATION PILOT STUDY, IRP SITE 1 (AECOM AND ECS 2011); FINAL GROUNDWATER FEASIBILITY STUDY, IRP SITES 1 AND 2 (AECOM 2011); AND SUPPLEMENTAL GROUNDWATER MONITORING, JANUARY 2013.
2. FOR THE WELLS FOR WHICH TWO CONCENTRATION VALUES ARE REPORTED, THE FIRST AND SECOND REPORTED VALUES ARE BASED ON THE GROUNDWATER MONITORING EVENTS CONDUCTED PRIOR TO AND AFTER THE COMPLETION OF THE IN-SITU BIOREMEDIATION PILOT STUDY, RESPECTIVELY.
3. DOWNGRADIENT EXTENT OF THE REACTION ZONE IS LIKELY TO EXCEED THE EXTENT SHOWN ON THE FIGURE DUE TO ADVECTION

<	LESS THAN
µg/L	MICROGRAMS PER LITER
DON	DEPARTMENT OF THE NAVY
EOD	EXPLOSIVE ORDNANCE DISPOSAL
FBI	FEDERAL BUREAU OF INVESTIGATION
IRP	INSTALLATION RESTORATION PROGRAM
MCAS	MARINE CORPS AIR STATION
NS	NOT SAMPLED
PRB	PERMEABLE REACTIVE BARRIER
ROI	RADIUS OF INFLUENCE

Summary of Substrate Injection Strategy – Intermediate Area PRB [a]

Injection Wells	Dilution Ratio of Substrate with Water (by volume)	Number of Parts of Chase Water Injected Per 1 Part of Dilute Substrate	Volume of Dilute EDS-ER+ Water (gallons)	Total Volume of Chase Water (gallons)
01-DPT01, 01-DPT02, 01-DPT03, 01-DPT04, 01-DPT05, 01-DPT06, 01-DPT07, 01-DPT08, 01-DPT09, 01-DPT10, 01-MW231	5:1	10	2,706 (246)[b]	2,7059 (2,459)[b]

Notes:
a. See main text of the Remedial Design/Remedial Action Work Plan for detailed injection approach.
b. Total volume in all listed injection points (Volume in each injection point).
EDS-ER Electron Donor Substrate – Extended Release
PRB Permeable Reactive Barrier

Groundwater RD/RA Work Plan — Final

Intermediate PRB Design – IRP Site 1
Perchlorate - Impacted Groundwater

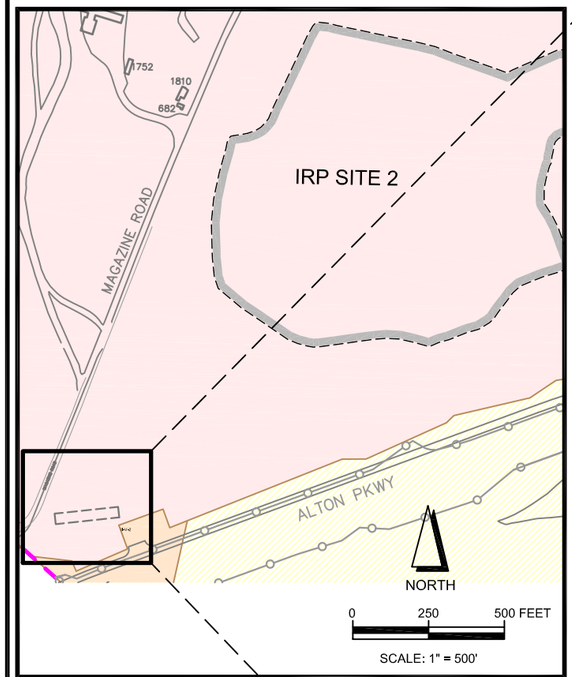
IRP Sites 1 & 2

Date: 12-13 | Former MCAS El Toro | Figure 6-5

Project No. 60225245

AECOM-ENVIROCON JOINT VENTURE

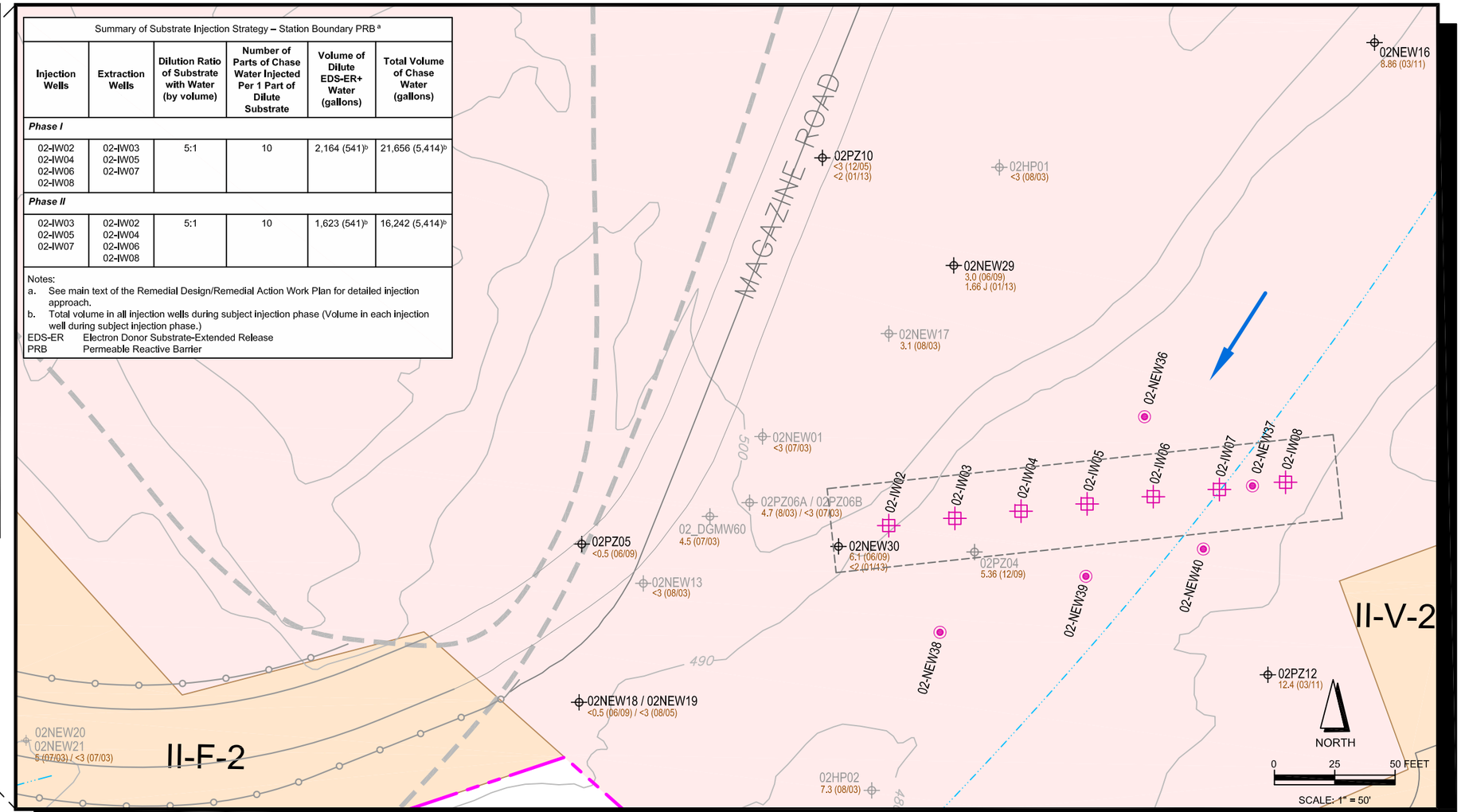
File: P:\60225245 – PERMAC II El Toro Sites 1 and 2 GW\7.0 Deliverables\7.2 CADD\RD.RA Work Plan\Final\FIGURE 6-5A.dwg Time: Dec 05, 2013 – 9:18am



Summary of Substrate Injection Strategy – Station Boundary PRB [a]

Injection Wells	Extraction Wells	Dilution Ratio of Substrate with Water (by volume)	Number of Parts of Chase Water Injected Per 1 Part of Dilute Substrate	Volume of Dilute EDS-ER+ Water (gallons)	Total Volume of Chase Water (gallons)
Phase I					
02-IW02 02-IW04 02-IW06 02-IW08	02-IW03 02-IW05 02-IW07	5:1	10	2,164 (541)[b]	21,656 (5,414)[b]
Phase II					
02-IW03 02-IW05 02-IW07	02-IW02 02-IW04 02-IW06 02-IW08	5:1	10	1,623 (541)[b]	16,242 (5,414)[b]

Notes:
a. See main text of the Remedial Design/Remedial Action Work Plan for detailed injection approach.
b. Total volume in all injection wells during subject injection phase (Volume in each injection well during subject injection phase.)
EDS-ER Electron Donor Substrate-Extended Release
PRB Permeable Reactive Barrier



STATION BOUNDARY PRB DESIGN

LEGEND:

- PROPOSED INJECTION WELL
- PROPOSED MONITORING WELL
- 01-MW206 — EXISTING WELL OR PIEZOMETER (PERCHLORATE CONCETRATION IS SHOWN IN µg/L)
- 01-MW201 — ABANDONED/DESTROYED WELL OR PIEZOMETER (PERCHLORATE CONCENTRATION IS SHOWN IN µg/L) (SEE NOTES 1 AND 2)
- MCAS EL TORO BOUNDARY
- EOD RANGE BOUNDARY
- 10-FOOT SECURITY FENCE
- IRP SITE BOUNDARY (1, 2, AND 17)
- EPHEMERAL STREAM OR WASH (INTERPOLATED FROM TOPOGRAPHIC DATA)
- TARGET IN-SITU REACTION ZONE BASED ON DESIGN ROI'S (SEE NOTE 3)
- GENERAL GROUNDWATER FLOW DIRECTION
- TRANSFERRED AREA
- DON OWNED
- FBI OWNED
- II-V-2 — CARVE-OUT NUMBER

NOTES:

1. FOR THE WELLS FOR WHICH ONE CONCENTRATION VALUE IS REPORTED, THE REPORTED VALUE IS THE LATEST AVAILABLE BASED ON THE FOLLOWING REPORTS/ SAMPLING EVENTS: SPRING 2011 SUMMARY REPORT, IRP SITES 1 AND 2 (TREVET 2011); TECHNICAL MEMORANDUM, IN-SITU BIOREMEDIATION PILOT STUDY, IRP SITE 1 (AECOM AND ECS 2011); FINAL GROUNDWATER FEASIBILITY STUDY, IRP SITES 1 AND 2 (AECOM 2011); AND SUPPLEMENTAL GROUNDWATER MONITORING, JANUARY 2013.
2. FOR THE WELLS FOR WHICH TEO CONCENTRATION VALUES ARE REPORTED, THE FIRST AND SECOND REPORTED VALUES ARE BASED ON THE GROUNDWATER MONITORING EVENTS CONDUCTED PRIOR TO AND AFTER THE COMPLETION OF THE IN-SITU BIOREMEDIATION PILOT STUDY, RESPECTIVELY.
3. DOWNGRADIENT EXTENT OF THE REACTION ZONE IS LIKELY TO EXCEED THE EXTENT SHOWN ON THE FIGURE DUE TO ADVECTION.

< LESS THAN
µg/L MICROGRAMS PER LITER
DON DEPARTMENT OF THE NAVY
EOD EXPLOSIVE ORDNANCE DISPOSAL
FBI FEDERAL BUREAU OF INVESTIGATION
IRP INSTALLATION RESTORATION PROGRAM
MCAS MARINE CORPS AIR STATION
NS NOT SAMPLED
ROI RADIUS OF INFLUENCE

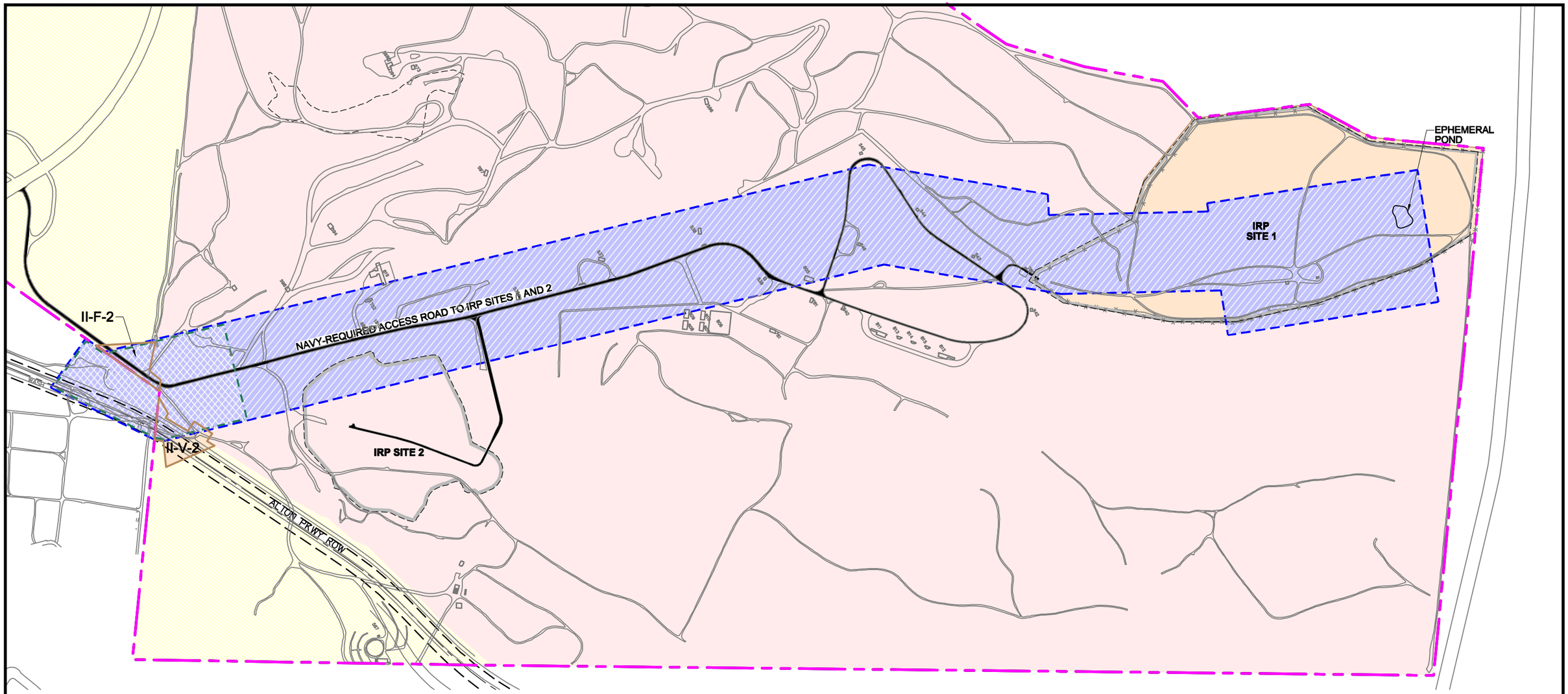
Groundwater RD/RA Work Plan — Final

Station Boundary PRB Design – IRP Site 1
Perchlorate - Impacted Groundwater

IRP Sites 1 & 2

Date: 12-13	Former MCAS El Toro	Figure
Project No. 60225245	AECOM-ENVIROCON JOINT VENTURE	6-6

File: P:\60225245 – PERMAC II El Toro Sites 1 and 2 GW\7.0 Deliverables\7.2 CADD\RD.RA Work Plan\Final\FIGURE 6-6A.dwg Time: Dec 09, 2013 – 1:50pm



LEGEND:

- ARIC FOR IRP SITE 1 PERCHLORATE - IMPACTED GROUNDWATER
- ARIC FOR IRP SITE 2 VOC IMPACTED GROUNDWATER; THIS ARIC OVERLIES THE ARIC FOR IRP SITE 1 PERCHLORATE-IMPACTED GROUNDWATER
- DON OWNED
- FBI OWNED
- TRANSFERRED AREA
- FORMER MCAS EL TORO BOUNDARY
- IRP SITE BOUNDARY (1 AND 2)
- EXISTING FENCE
- II-V-2 CARVE-OUT NUMBER

NOTES:

DON DEPARTMENT OF THE NAVY
FBI FEDERAL BUREAU OF INVESTIGATION
IRP INSTALLATION RESTORATION PROGRAM
MCAS MARINE CORPS AIR STATION
ROW RIGHT OF WAY
VOC VOLATILE ORGANIC COMPOUND

NORTH

0 350 700 FEET

SCALE: 1" = 700'

Groundwater RD/RA Work Plan — Final

Areas Requiring Institutional Controls for Groundwater at IRP Sites 1 and 2

IRP Sites 1 & 2

Date: 12-13	Former MCAS El Toro	Figure
Project No. 60225245	AECOM-ENVIROCON JOINT VENTURE	6-7

File: P:\60225245 – PERMAC II El Toro Sites 1 and 2 GW\7.0 Deliverables\7.2 CADD\RD.RA Work Plan\Final\FIGURE 6–7.dwg Time: Dec 05, 2013 – 9:20am

IRP SITE 2

AREA C2

AREA D2

II-F -2

II-V-2

MAGAZINE RD.

ALTON PKWY ROW

02PZ01

02PZ03

02NEW15

02PZ02

02NEW08A

02-NEW41

02NEW16

02DGMW59

02PZ10

02NEW29

02-NEW36

02-IW06

02-IW07

02-IW08

02-NEW37

02-NEW40

02-IW05

02-IW03

02NEW34A

02-IW02

02-IW04

02PZ05

02NEW30

02-NEW38

02-NEW39

02PZ12

02NEW18

02NEW19

02-NEW42

02-NEW28A

02_NEW02A

02_NEW26A

02_NEW07A

02_NEW27A

LEGEND

- EXISTING MONITORING WELL LOCATION
- EXISTING PIEZOMETER LOCATION
- PROPOSED MONITORING WELL - IRP SITE 2 MNA
- PROPOSED INJECTION WELL - IRP SITE 1 ISB
- PROPOSED MONITORING WELL - IRP SITE 1 ISB
- FORMER DISPOSAL LOCATIONS CONSOLIDATED INTO FORMER OPERATIONAL LANDFILL
- DON OWNED
- FBI OWNED
- TRANSFERRED AREA
- II-V-2 CARVE-OUT NUMBER
- FORMER MCAS EL TORO BOUNDARY
- IRP SITE 2 BOUNDARY
- 3-STRAND WIRE FENCE
- 6-FOOT CHAIN LINK FENCE
- 10-FOOT SECURITY FENCE
- IMPROVED ROADS
- UNIMPROVED ROADS
- TCE ABOVE 5 µg/L (DASHED WHERE INFERRED)
- INFERRED LOWER HYDRAULIC CONDUCTIVITY ZONE WITHIN BEDROCK

NOTES

DON DEPARTMENT OF NAVY
FBI FEDERAL BUREAU OF INVESTIGATION
IRP INSTALLATION RESTORATION PROGRAM
MCAS MARINE CORPS AIR STATION
ROW RIGHT OF WAY

NORTH

0 100 200 FEET

SCALE: 1" = 200'

Groundwater RD/RA Work Plan — Final

Proposed Monitoring Wells IRP Site 2 MNA

IRP Sites 1 & 2

Former MCAS El Toro

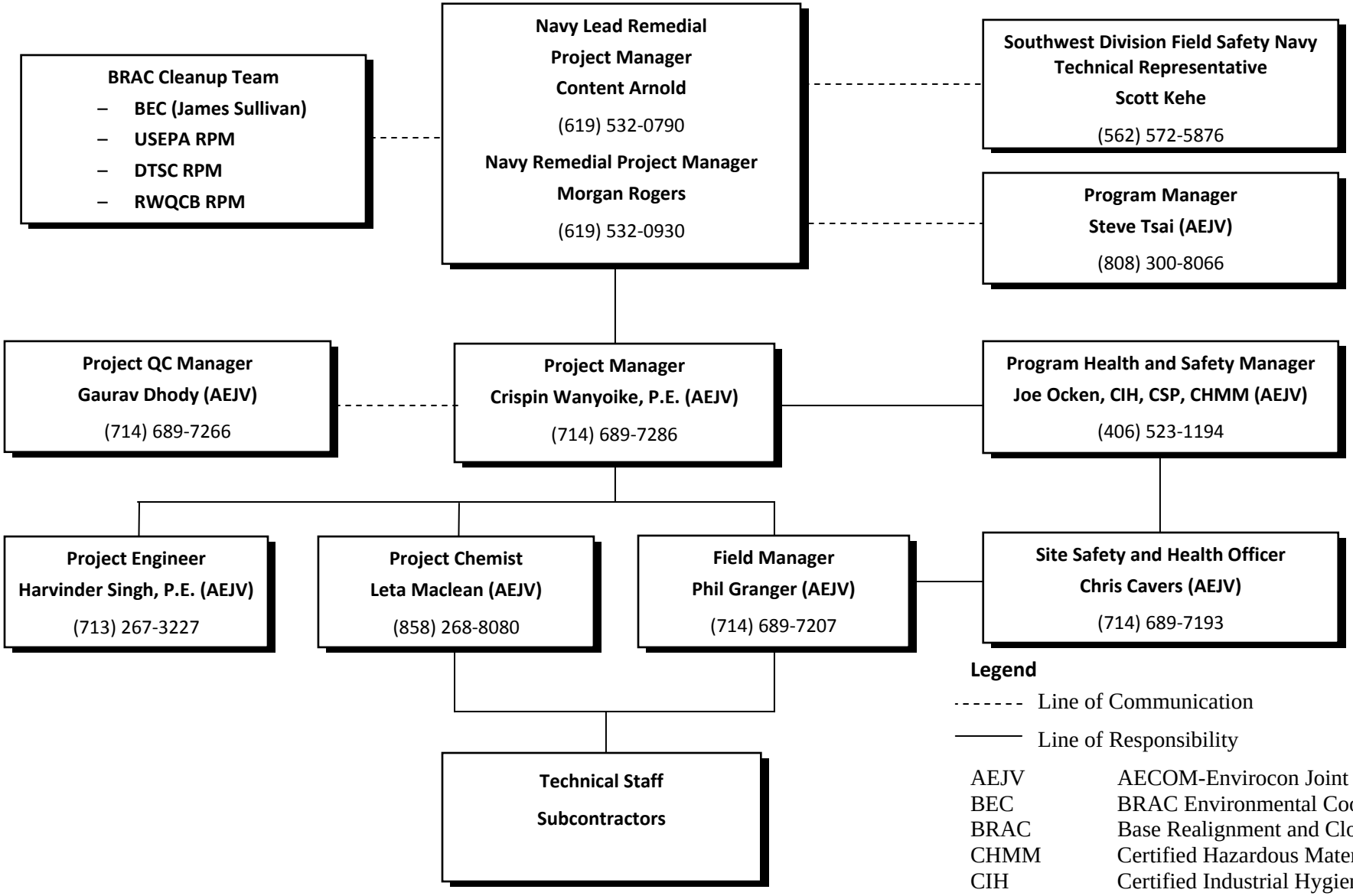
Date: 12-13

Project No. 60225245

AECOM-ENVIROCON JOINT VENTURE

Figure 7-1

File: P:\60225245 – PERMAC II El Toro Sites 1 and 2 GW\7.0 Deliverables\7.2 CADD\RD.RA Work Plan\Final\FIGURE 7–1.dwg Time: Dec 10, 2013 – 8:32am



Legend

- - - - - - - Line of Communication

——— Line of Responsibility

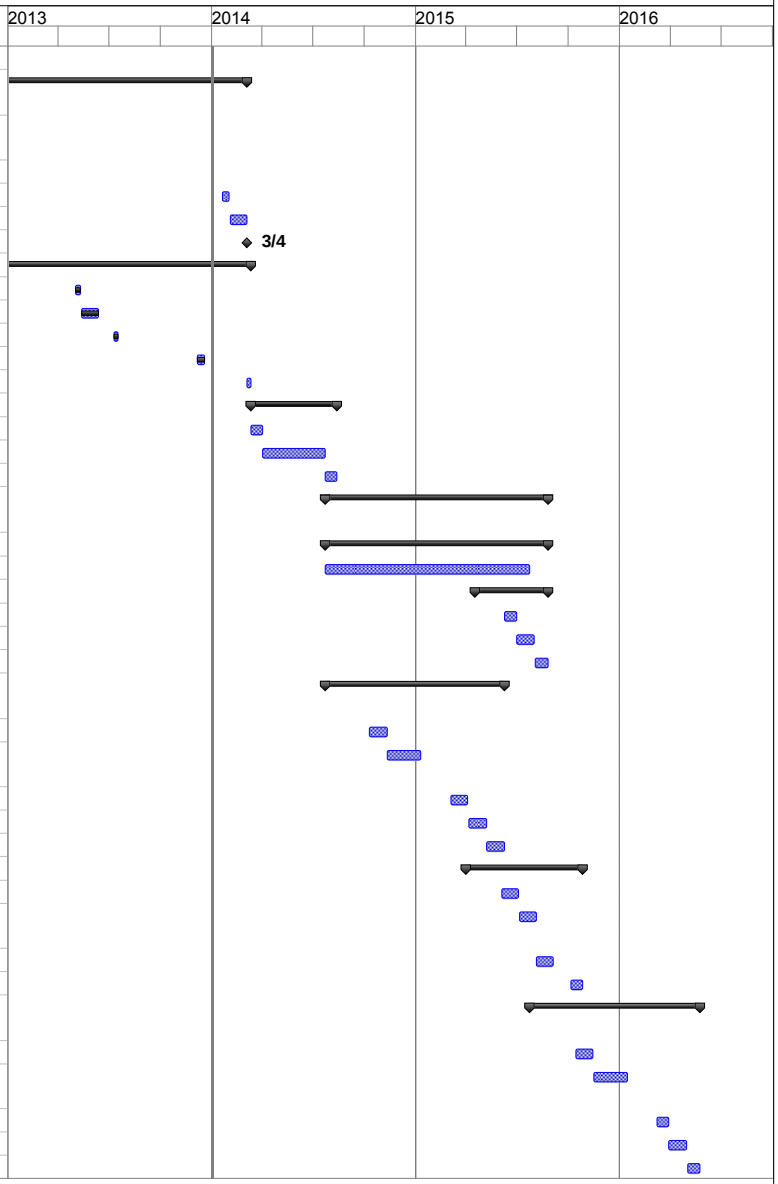
AEJV	AECOM-Envirocon Joint Venture.
BEC	BRAC Environmental Coordinator
BRAC	Base Realignment and Closure
CHMM	Certified Hazardous Materials Manager
CIH	Certified Industrial Hygienist
CSP	Certified Safety Professional
DTSC	Department of Toxic Substances Control
P.E.	Professional Engineer
RWQCB	Regional Water Quality Control Board
USEPA	United States Environmental Protection Agency

Figure 8-1: Organization Chart

El Toro _Comprehensive_01-2014_wd01.mpp

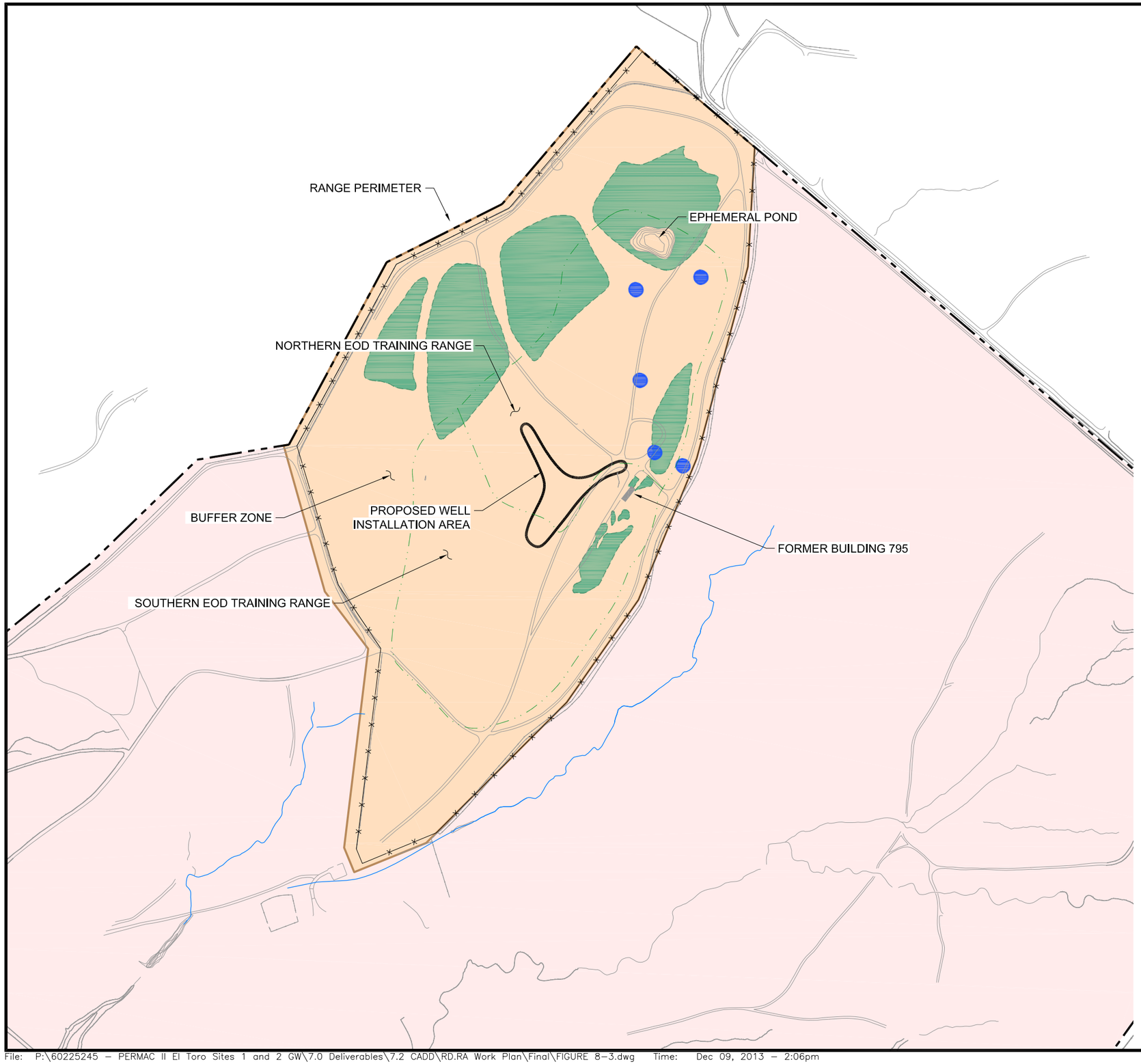
Figure 8-2: Project Schedule

ID	Task Name	Duration	Start	Finish
2089	Final ROD	0 days	Wed 2/15/12	Wed 2/15/12
2090	**Remedial Design/ Action Work Plan (RD/RA- WP)**	**558 days**	**Fri 1/13/12**	**Tue 3/4/14**
2093	Draft (RD/RA- WP) - Preliminary Remedial Design	25 days	Wed 5/2/12	Tue 6/5/12
2095	Regulatory Agency Review	58 days	Wed 6/6/12	Fri 8/24/12
2103	Draft Final (RD/RA- WP)	10 days	Mon 1/20/14	Fri 1/31/14
2105	Regulatory Agency Concur/Dispute	22 days	Mon 2/3/14	Tue 3/4/14
2106	Final (RD/RA- WP)	0 days	Tue 3/4/14	Tue 3/4/14
2108	**Remedial Action (RA) Fact Sheet**	**372 days**	**Mon 10/8/12**	**Tue 3/11/14**
2111	Draft RA Fact Sheet	7 days	Thu 5/2/13	Fri 5/10/13
2113	Regulatory Agency Review	22 days	Mon 5/13/13	Tue 6/11/13
2116	Draft Final RA Fact Sheet	5 days	Wed 7/10/13	Tue 7/16/13
2118	Regulatory Agency Concur/Dispute	9 days	Fri 12/6/13	Wed 12/18/13
2119	Final RA Fact Sheet	5 days	Wed 3/5/14	Tue 3/11/14
2121	**Remedial Action Construction**	**110 days**	**Wed 3/12/14**	**Tue 8/12/14**
2122	Mobilization	15 days	Wed 3/12/14	Tue 4/1/14
2123	Implementation	80 days	Wed 4/2/14	Tue 7/22/14
2124	Site Restoration	15 days	Wed 7/23/14	Tue 8/12/14
2125	**Remedial Action Operations/Long Term Monitoring**	**285 days**	**Wed 7/23/14**	**Tue 8/25/15**
2126	**Year 1 (2013-2014)**	**285 days**	**Wed 7/23/14**	**Tue 8/25/15**
2127	Routine Monitoring/Sampling/Reporting	262 days	Wed 7/23/14	Thu 7/23/15
2128	**Annual Report (2013-2014)**	**93 days**	**Fri 4/17/15**	**Tue 8/25/15**
2131	Draft Annual Report	16 days	Tue 6/9/15	Tue 6/30/15
2132	Regulatory Agency Review	23 days	Wed 7/1/15	Fri 7/31/15
2133	Final Annual Report	17 days	Mon 8/3/15	Tue 8/25/15
2134	**Interim Remedial Action Completion Report (I-RACR)**	**229 days**	**Wed 7/23/14**	**Mon 6/8/15**
2137	Draft I-RACR	22 days	Fri 10/10/14	Mon 11/10/14
2139	Regulatory Agency Review (Appendix A : 10/30/13)	44 days	Tue 11/11/14	Fri 1/9/15
2142	Draft Final I-RACR	22 days	Thu 3/5/15	Fri 4/3/15
2143	Regulatory Agency Concur/Dispute	24 days	Mon 4/6/15	Thu 5/7/15
2144	Final I-RACR	22 days	Fri 5/8/15	Mon 6/8/15
2146	**Long Term Monitoring (LTM) Plan**	**149 days**	**Wed 4/1/15**	**Mon 10/26/15**
2149	Draft LTM Plan	22 days	Thu 6/4/15	Fri 7/3/15
2151	Regulatory Agency Review (Appendix A : 6/24/14)	22 days	Mon 7/6/15	Tue 8/4/15
2152	Response to Comments	22 days	Wed 8/5/15	Thu 9/3/15
2154	Final LTM Plan	15 days	Tue 10/6/15	Mon 10/26/15
2156	**Operating Properly and Successfully (OPS) Demonstration Report**	**217 days**	**Fri 7/24/15**	**Mon 5/23/16**
2159	Draft OPS Demonstration Report	22 days	Thu 10/15/15	Fri 11/13/15
2161	Regulatory Agency Review (Appendix A : 11/4/14)	44 days	Mon 11/16/15	Thu 1/14/16
2164	Draft Final OPS Demonstration Report	15 days	Tue 3/8/16	Mon 3/28/16
2165	Regulatory Agency Concur/Dispute	24 days	Tue 3/29/16	Fri 4/29/16
2166	Final OPS Demonstration Report	16 days	Mon 5/2/16	Mon 5/23/16



Project: Former MCAS El Toro
Date:Thu 1/2/14

Task | Summary | Progress
Milestone | Project Summary



LEGEND

- MCAS EL TORO BOUNDARY
- SECURITY FENCE/ IRP SITE 1 BOUNDARY
- EXPLOSIVE ORDNANCE DISPOSAL (EOD) TRAINING RANGE BOUNDARY
- STREAM OR WASH
- DON OWNED
- FBI OWNED
- LOCATION OF COASTAL SAGE SCRUB BASED ON HABITAT ASSESSMENT AT SITE 1 CONDUCTED IN DECEMBER, 2000 BY LINCER & ASSOCIATES, (LINCER AND ASSOCIATES 2001)
- PROPOSED WELL INSTALLATION AREA
- PROPOSED INJECTION USING EXISTING WELLS

NOTES

DON	DEPARTMENT OF THE NAVY
FBI	FEDERAL BUREAU OF INVESTIGATION
IRP	INSTALLATION RESTORATION PROGRAM
MCAS	MARINE CORPS AIR STATION

NORTH

0 200 400 FEET

SCALE: 1" = 400'

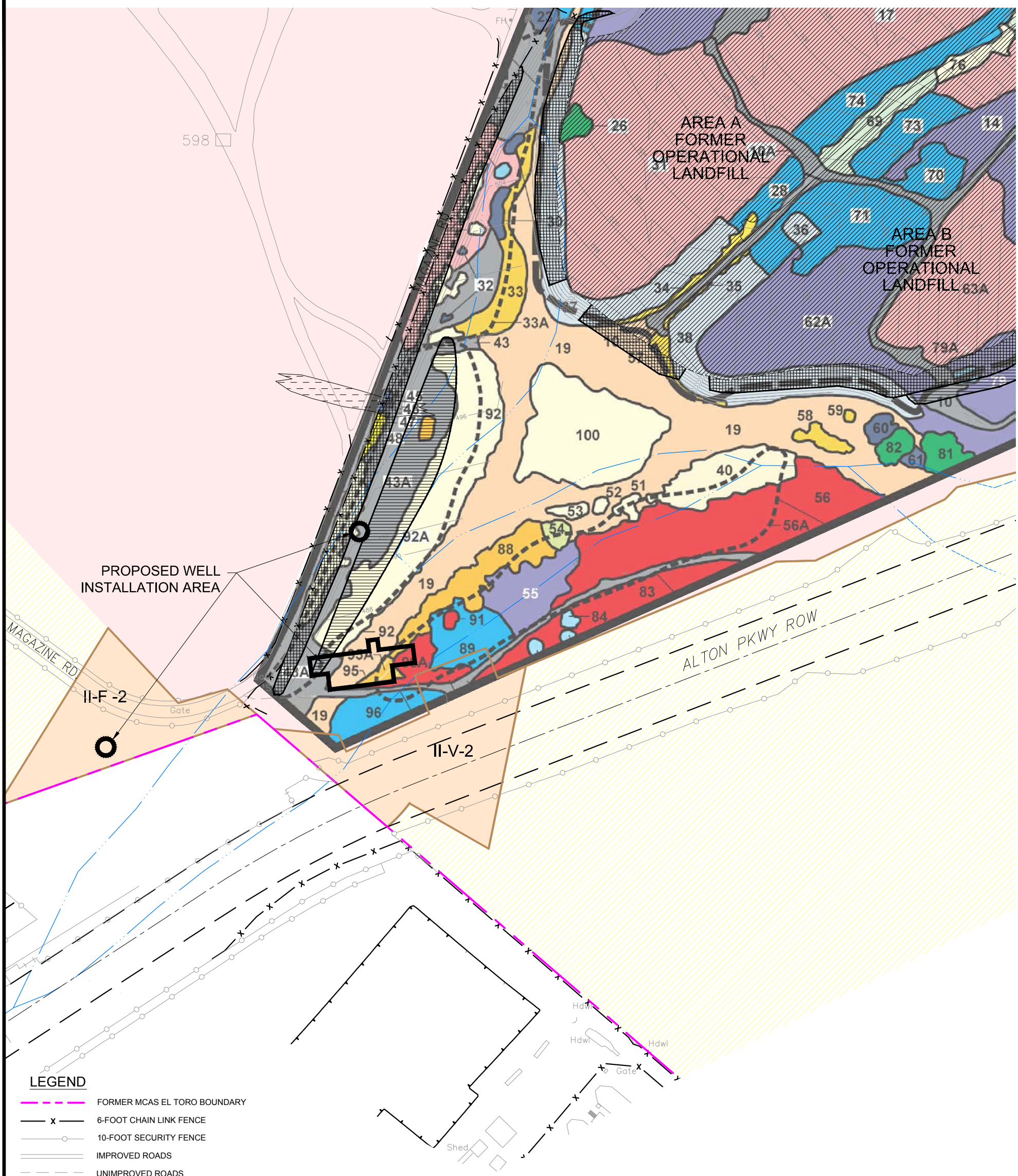
Groundwater RD/RA Work Plan — Final

Previously Mapped Coastal Sage Scrub Locations, IRP Site 1

IRP Sites 1 & 2

Date: 12-13	Former MCAS El Toro	Figure
Project No. 60225245	AECOM-ENVIROCON JOINT VENTURE	8-3

File: P:\60225245 – PERMAC II El Toro Sites 1 and 2 GW\7.0 Deliverables\7.2 CADD\RD.RA Work Plan\Final\FIGURE 8-3.dwg Time: Dec 09, 2013 – 2:06pm



LEGEND

- FORMER MCAS EL TORO BOUNDARY
- 6-FOOT CHAIN LINK FENCE
- 10-FOOT SECURITY FENCE
- IMPROVED ROADS
- UNIMPROVED ROADS
- II-V-2 CARVE-OUT NUMBER
- DON OWNED
- FBI OWNED
- TRANSFERRED AREA
- PROPOSED WELL INSTALLATION LOCATION AREA
- VENTURA/DIEGAN TRANSITIONAL COASTAL SAGE SCRUB
- DISTURBED VENTURA/DIEGAN TRANSITIONAL COASTAL SAGE SCRUB
- MULE FAT SCRUB - DENSE
- MULE FAT SCRUB - SPARSE
- MULE FAT SCRUB - MIXED (MFS, BEW AND/OR WNN)
- BLUE ELDERBERRY WOODLAND
- UNVEGETATED
- SPARSELY VEGETATED
- SOUTHERN COAST LIVE OAK/SYCAMORE RIPARIAN FOREST
- EUCALYPTUS
- FRESHWATER MARSH
- RUDERAL - <10% CSS
- REDERAL - NO CSS
- WOODY NON-NATIVE
- INDIVIDUAL M. laurina BUSHES
- SANDY WASH
- ESTIMATED LIMIT OF HISTORIC LANDFILL
- MAXIMUM LIMITS OF REMEDIATION IMPACTS
- CSS/GRASSLAND
- MULEFAT RESTORATION AREAS
- CSS-RESTORATION

NORTH

0 100 200 FEET

SCALE: 1" = 200'

SOURCE:
BIOLOGICAL ASSESSMENT, REMEDIAL ACTION, OPERABLE UNIT 2B, LANDFILL SLOPES 2 AND 17, FORMER MCAS EL TORO (EARTHTECH AND LINCER 2001)

NOTES

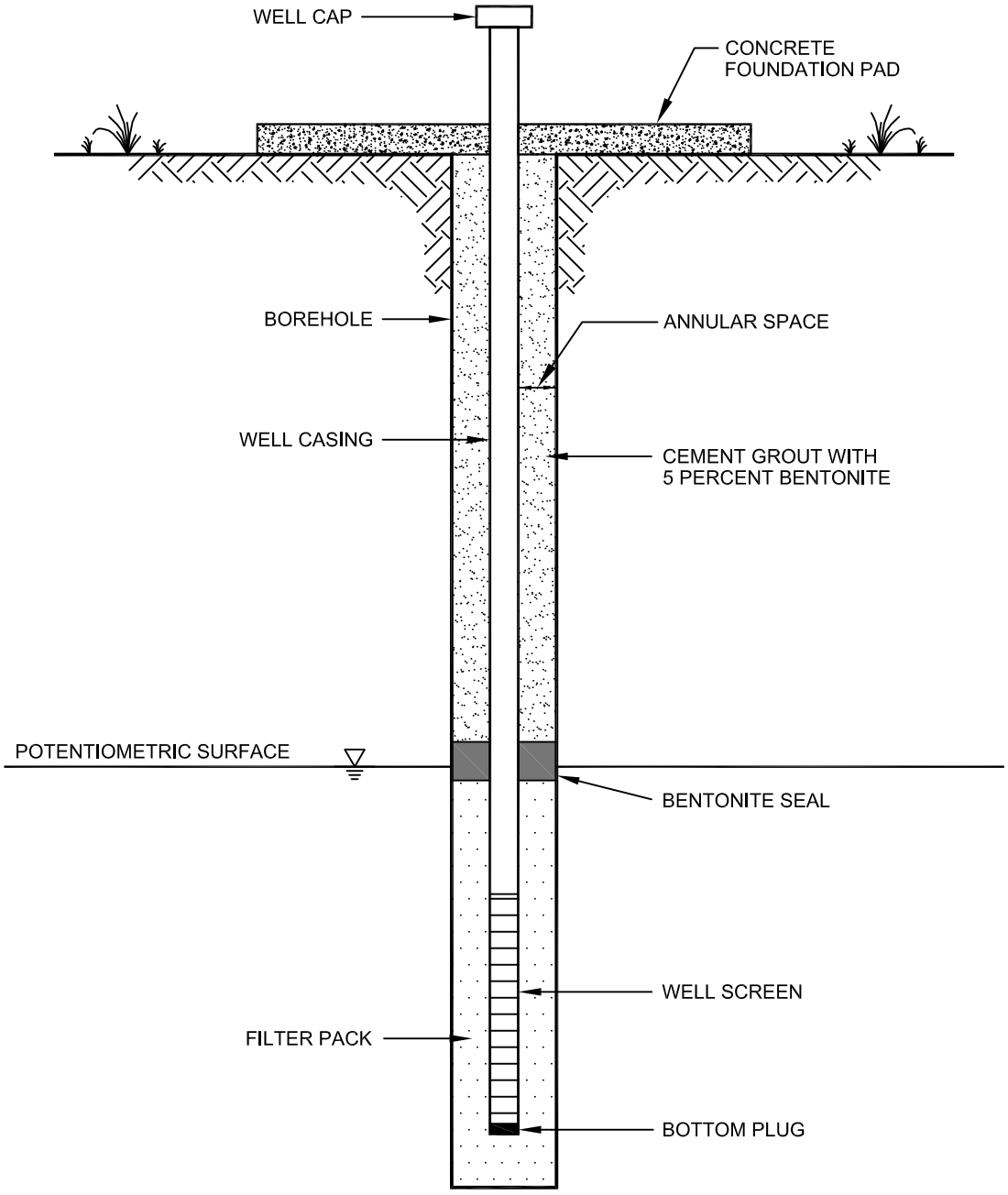
DON	DEPARTMENT OF THE NAVY
EOD	EXPLOSIVE ORDNANCE DISPOSAL
FBI	FEDERAL BUREAU OF INVESTIGATION
FT	FOOT
IRP	INSTALLATION RESTORATION PROGRAM
MCAS	MARINE CORPS AIR STATION
PKWY	PARKWAY
RD	ROAD
ROW	RIGHT OF WAY

Groundwater RD/RA Work Plan — Final

Vegetation Types
IRP Site 2

IRP Sites 1 & 2

Date: 12-13	Former MCAS El Toro	Figure
Project No. 60225245	AECOM-ENVIROCON JOINT VENTURE	8-4



NOT TO SCALE

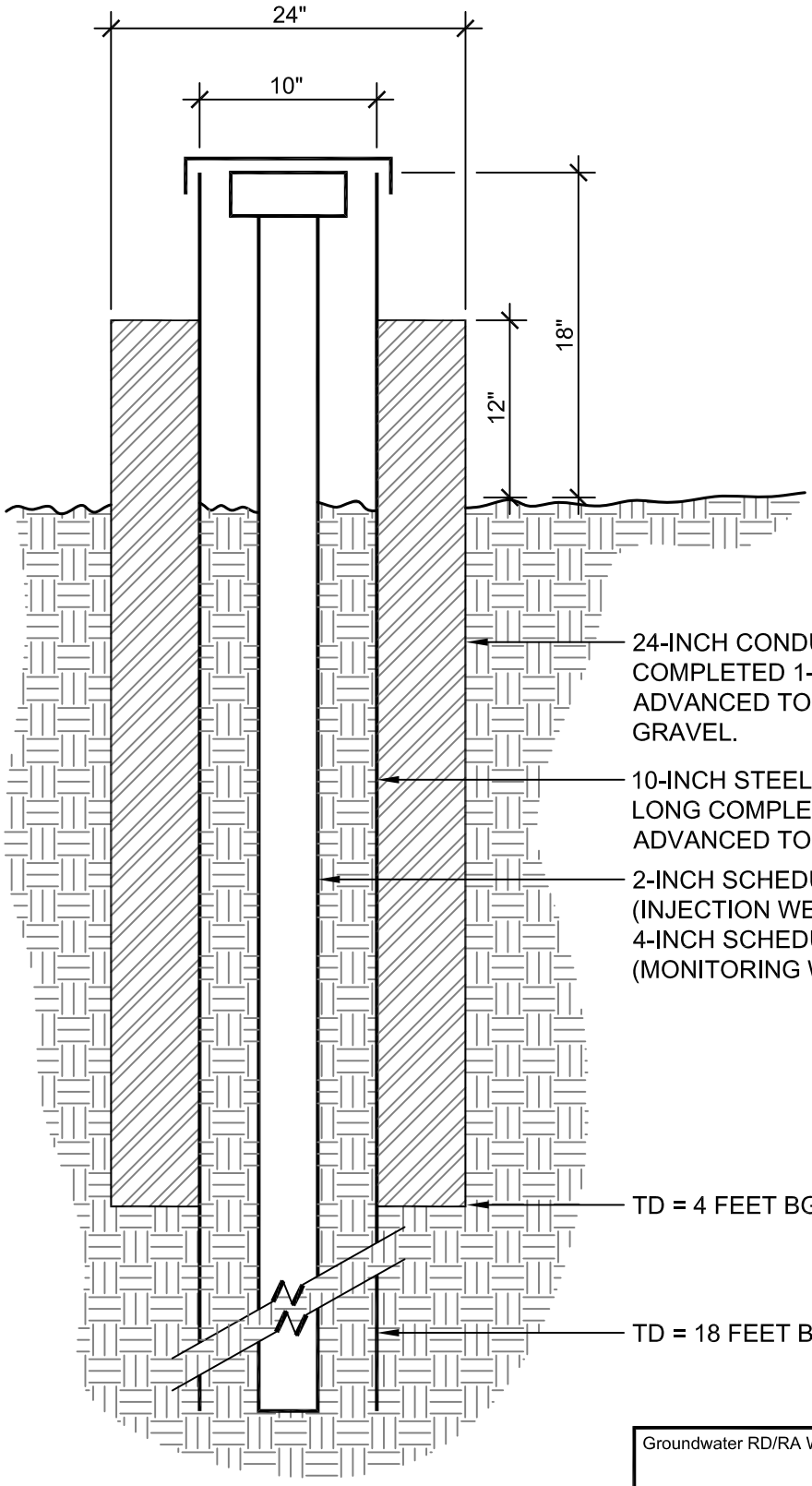
Groundwater RD/RA Work Plan — Final

Typical Injection/Monitoring Well Construction Diagram

IRP Site 1 & 2

Date: 12-13	Former MCAS El Toro	Figure
Project No. 60225245	AECOM-ENVIROCON JOINT VENTURE	8-5

File: P:\60225245 – PERMAC II El Toro Sites 1 and 2 GW\7.0 Deliverables\7.2 CADD\RD.RA Work Plan\Final\FIGURE 8-5.dwg Time: Dec 05, 2013 – 9:54am



Groundwater RD/RA Work Plan — Final

Conceptual Design,
IRP Site 2 Well Protection

IRP Site 1 & 2

Date: 12-13	Former MCAS El Toro	Figure
Project No. 60225245	AECOM-ENVIROCON JOINT VENTURE	8-6

File: P:\60225245 – PERMAC II El Toro Sites 1 and 2 GW\7.0 Deliverables\7.2 CADD\RD.RA Work Plan\Final\FIGURE 8-6.dwg Time: Dec 10, 2013 – 8:24am

Tables

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Table 2-1: Previous Groundwater Investigations at IRP Site 1

Study/Investigation	Year(s) Conducted	Investigation Activities
Phase I Remedial Investigation (RI)	1993	Limited soil and groundwater sampling was conducted. No further investigation was recommended at Installation Restoration Program (IRP) Site 1 until Station closure. Results indicated that human-health or ecological risk thresholds were not exceeded.
Stationwide Perchlorate Investigation	1999	Existing groundwater monitoring wells at IRP Site 1 were sampled. Results indicated the presence of perchlorate exceeding the State Provisional Action Level (PAL) (in effect in 1999) in one well (01-MW201) at IRP Site 1. Further evaluation of IRP Site 1 was recommended.
Verification of Perchlorate at IRP Site 1	1999-2000	Six groundwater monitoring wells were installed and shallow and deep soil samples were collected and analyzed. Soil and groundwater samples were collected from new and existing wells were analyzed for perchlorate. Results confirmed the presence of perchlorate exceeding the State and Federal PAL (in effect in 1999) in one well (01-MW201). All reported concentrations of perchlorate in the soil were below residential preliminary remediation goals (PRGs).
Phase II Stationwide Evaluation of Radionuclides	2001	Investigation was conducted to confirm whether radionuclides in groundwater at former Marine Corps Air Station (MCAS) El Toro were due to anthropogenic or naturally occurring sources. In addition to selected wells at former landfill sites, three wells within IRP Site 1 were sampled. Investigation concluded that that the origin of radionuclides reported in groundwater is natural.
Phase II RI	2002-2005	More than 30 groundwater monitoring wells/piezometers were installed and extensive Hydropunch sampling was conducted. Multiple groundwater monitoring rounds were conducted. A conceptual site model was developed that included site physical characteristics, nature and extent of perchlorate in groundwater, and risks to human-health and the environment.
Aquifer Characterization and Bench-Scale Treatability Testing	2005	15 extraction wells/piezometers were installed in the central portion of IRP Site 1. Short- and long-term pumping tests were conducted to characterize the hydrogeology. In addition, laboratory scale microcosm studies were conducted to evaluate the biodegradation of perchlorate. These studies indicated that rapid and complete degradation of perchlorate occurred when the oxidation-reduction potential was reduced by adding a carbon source to the subsurface.
Stationwide Semi-Annual Groundwater Monitoring	1992 to Present	Monitoring is conducted to periodically evaluate perchlorate and volatile organic compound (VOC) concentration trends in groundwater.
In Situ Bioremediation ISB Pilot Study	2009-2010	Investigation included field-scale evaluation of ISB of perchlorate in groundwater at and downgradient of IRP Site 1. Groundwater injection/monitoring wells were installed and bioremediation substrate was injected. Substrate injections were performed following hydraulic fracturing, which increased the permeability of the subsurface. A primary conclusion of the pilot study was that naturally occurring perchlorate-degrading bacteria can be readily stimulated using commercially available bioremediation amendments to reduce concentrations of perchlorate to less than its Maximum Contaminant Level (MCL) of 6 micrograms per liter (µg/L).
Groundwater Feasibility Study (FS)	2011	This study developed and evaluated remedial alternatives for perchlorate-impacted groundwater at IRP Site 1.

Note: The documents listed are available at the Administrative Record File; they provide detailed information used to support the remedy selection at IRP Site 1.

Table 2-2: Previous Groundwater Investigations at IRP Site 2

Study/Investigation	Year(s) Conducted	Investigation Activities
Phase I Remedial Investigation (RI)	1993	Investigations included installing and sampling groundwater monitoring wells upgradient and downgradient of the Installation Restoration Program (IRP) Site 2 landfill. VOCs, including trichloroethene (TCE) and tetrachloroethene (PCE) were reported in groundwater at concentrations exceeding their respective MCLs.
Phase II RI	1996	Investigations included soil, groundwater, surface water, and air sampling and analyses. A conceptual site model was developed that included site physical characteristics, nature and extent of VOCs in groundwater, and risks to human-health and the environment. VOCs, including TCE and PCE, were reported in groundwater at concentrations exceeding their respective MCLs.
Phase II Feasibility Study (FS)	1997	This study developed and evaluated remedial alternatives for the landfill and associated impacted groundwater.
Final Interim Record of Decision (ROD)	2000	Presented the selected remedy for the vadose zone of IRP Site 2. The selected remedy included construction of a landfill cap and land-use restrictions. The selection of groundwater remedy for IRP Site 2 was postponed to a later date.
Phase II Stationwide Evaluation of Radionuclides	2001	Conducted to confirm whether radionuclides in groundwater at former Marine Corps Air Station (MCAS) El Toro were due to anthropogenic or naturally occurring sources. In addition to selected wells at former landfill sites, three wells within IRP Site 1 were sampled. Investigation concluded that origin of radionuclides reported in groundwater is natural.
Microcosm Study	2005	Measured the rate and extent of biodegradation of VOCs and perchlorate in groundwater under anaerobic conditions. The study concluded that limited degradation of PCE and TCE would occur provided the oxidation-reduction potentials were artificially reduced below ambient levels.
Long-term Aquifer Test	2006	Multiple groundwater monitoring wells/piezometers were installed and sampled. Long-term aquifer test was conducted to characterize the hydrogeology.
Draft Final FS Addendum	2005	This Addendum incorporated supplemental results from the long-term aquifer test and developed and evaluated remedial alternatives for VOC-impacted groundwater.
Stationwide Annual Groundwater Monitoring	1992 to Present	Monitoring is conducted to periodically monitor VOC and perchlorate concentration trends in groundwater.
In Situ Bioremediation (ISB) Pilot Study	2009-2010	Included field-scale evaluation of ISB of TCE in groundwater. Groundwater injection/monitoring wells were installed and bioremediation substrates were injected. Substrate injections were performed using hydraulic fracturing to increase the permeability of the subsurface. A primary conclusion of the pilot study was that naturally occurring TCE-degrading bacteria can be stimulated using commercially available bioremediation amendments to reduce TCE concentrations to less than its MCL of 5 micrograms per liter (µg/L).
Groundwater FS	2011	This study developed and evaluated remedial alternatives for VOC-impacted groundwater at IRP Site 2.

Note: The documents listed are available at the Administrative Record File; they provide detailed information used to support remedy selection at IRP Site 2.

Table 3-1: Water Level Data Summary for Intermediate Area

Well ID	Depth to Water (feet below top of casing)			Groundwater Elevation (feet amsl)		
	November 2010	March 2011	January 2013	November 2010	March 2011	January 2013
01-MW211	45.80	39.19	44.6	501.77	508.38	502.97
01-MW215	35.72	33.77	33.84	559.64	561.59	561.52

Notes:
amsl above mean sea level
ID identification

Table 3-2: Geochemical Data (April 2010-March 2011) - IRP Sites 1 and 2 Groundwater

Well Identification	Screen Interval (feet bgs)	Sample Date	Sulfate (mg/L)	Nitrate (mg/L)	Alkalinity (as $CaCO_3$) (mg/L)	Dissolved Oxygen (mg/L)	ORP (mV)	pH
Within IRP Site 1 Boundary [a]								
01-MW202	10-35	Apr-10	182	7.58	170	6.0[b]	-28.0	6.86
		Nov-10	179	10.6	223	2.81	255.6	7.64
		Mar-11	342	10.5	222	6.59	207.8	7.25
01-MW203	33-58	Apr-10	40.9	18.8	214	8.0[b]	191.9	6.51
		Nov-10	51.6	16.2	206	3.45	143.1	7.99
		Mar-11	46.8	17.1	212	6.55	176.8	7.40
01-PZ06	55-80	Apr-10	13.2	9.97	177	3.64	-29.3	7.55
		Nov-10	13.8	7.3	191	0.4	80.8	7.30
		Mar-11	13.8	8.54	202	4.51	182.6	7.44
		Mar-11	*13.2*	*8.5*	*200*	--	--	--
01-MW201	27-57	Apr-10	39.6	22	198	2.83	6.4	7.83
		Nov-10	44.6	21.9	193	0.86	109.7	7.45
		Nov-10	*45.1*	*22.2*	*192*	--	--	--
		Mar-11	43.2	23.8	209	5.51	163.0	7.36
01-MW204	24-54	Apr-10	9.17	5.5	148	0.35	-221.2	6.98
		Apr-10	*9.22*	*5.53*	*149*	--	--	--
		Nov-10	9.4	5.59	148	3.71	199.7	7.11
		Mar-11	39.4	3.35	101	7.51	206.4	6.76
01-MW209	25-45	Apr-10	23.5	10.5	193	3.0[b]	-159.2	6.93
		Nov-10	23.5	9.85	190	2.1	487.1	6.79
		Mar-11	30.3	9.58	205	5.39	159.1	7.32
01-MW218	45-60	Apr-10	26	7.02	169	0.45	35.2	7.51
		Apr-10	*26.5*	*7.01*	*169*	--	--	--
		Nov-10	30.5	6.52	170	--	--	--
		Nov-10	*28.7*	*6.58*	*171*	1.09	90.9	7.43
		Mar-11	*32.9*	*6.46*	*189*	4.20	150.6	7.41
01-MW219	40-55	Apr-10	71.3	30.4	175	0.21	250.3	6.80
		Nov-10	71	31.2	174	0.82	420.1	7.06
		Mar-11	76.7	27	176	0.63	132.3	7.41
01-PZ07	30-55	Apr-10	90.6	22.1	175	8.0[b]	-131.4	7.03
		Nov-10	95.7	21.7	176	1.54	85.9	7.21
		Mar-11	65.9	16.2	200	6.64	169.8	7.29
01-PZ08	55-80	Apr-10	48.4	7.69	137	3.28	-23.1	7.51
		Nov-10	53.6	7.45	137	1.25	97.5	7.55
		Mar-11	49.7	7.17	143	6.84	75.7	7.69
01-PZ09	30-55	Apr-10	85.4	26	156	0.35	0.9	7.20
		Nov-10	88.8	21.5	163	0.75	90.1	6.91
		Mar-11	72.1	19.7	155	4.71	117.2	7.02
01-PZ11	35-60	Apr-10	35.8	16	183	0.61	14.8	7.38
		Nov-10	39.8	17.2	175	1.67	93.0	7.25
		Mar-11	52.9	44.4	187	7.36	132.9	7.36
01-PZ12	70-95	Apr-10	8.88	4.69	136	3.39	-24.4	7.66
		Nov-10	9	4.92	137	0.83	73.4	7.44
		Mar-11	11.9	7.05	150	6.17	147.6	7.55
01-EW03	40-70	Apr-10	35.7	10.9	147	3.28	8.7	7.61
		Nov-10	46.7	10.8	145	1.14	79.5	7.57
		Mar-11	63.7	10.5	142	6.07	106.5	7.56

Well Identification	Screen Interval (feet bgs)	Sample Date	Sulfate (mg/L)	Nitrate (mg/L)	Alkalinity (as $CaCO_3$) (mg/L)	Dissolved Oxygen (mg/L)	ORP (mV)	pH
Area Between IRP Sites 1 and 2								
01-MW211	50-60	Apr-10	175	4.98	274	0.56	7.5	7.27
		Nov-10	185	4.69	274	1.58	87.2	7.07
		Mar-11	170	4.11	385	4.2	167.5	7.23
		Mar-11	*174*	*4.12*	*302*	--	--	--
01-MW215	35-50	Apr-10	136	10.2	259	0.39	106.2	7.44
		Nov-10	122	9.64	255	1.45	90.3	7.22
		Mar-11	102	9.13	255	6.46	102.2	7.41
01-MW223	35-70	Apr-10	92.7	5.07	225	0.27	31.0	7.31
		Nov-10	98.2	5.16	226	1.12	88.7	7.07
		Mar-11	92	4.91	231	2.54	108.8	7.18
IRP Site 2 Area								
02_NEW02	75-95	Apr-10	247	4.56	280	0.41	46.6	6.97
		Nov-10	259	4.35	278	0.48	85.2	7.15
		Mar-11	No sample collected, well properly destroyed, February 2011.					
02_NEW08A	84-104	Apr-10	244	15.3	324	4.36	9.2	6.98
		Nov-10	214	17.7	360	0.46	59.6	6.42
		Mar-11	298	13.3	278	3.28	168.6	7.01
02_NEW16	25-65	Apr-10	241	8.02	349	4.01	16.7	6.91
		Nov-10	245	8.18	344	0.42	52.5	6.52
		Mar-11	242	8.12	352	4.74	129.4	7.00
02_NEW19	86-113	Apr-10	137	0.0905 J	256	0.43	169.7	7.53
		Nov-10	143	0.1 U	267	0.1	15.0	7.44
		Mar-11	157	0.1 U	312	0.49	39.4	7.29
02_NEW26	70-95	Apr-10	138	4.45	445	0.59	-16.1	6.68
		Nov-10	161	5.82	422	0.67	87.0	6.89
		Nov-10	*159*	*5.82*	*423*			
		Mar-11	No sample collected, well properly destroyed, February 2011.					
02_NEW29	47-67	Apr-10	226	18.7	419	4.92	22.2	6.83
		Nov-10	233	22.3	450	0.36	83.3	6.29
		Mar-11	237	19.1	446	5.17	152.2	6.87
02PZ12	60-80	Apr-10	217	7.35	302	--	-3.4	7.18
		Apr-10	*217*	*7.35*	*301*	--	--	--
		Nov-10	231	7.53	301	0.73	84.9	7.16
		Mar-11	235	7.23	266	3.49	93.7	7.07

Notes:

Results compiled from Final Spring 2011 Data Summary Report, Installation Restoration Program Sites 1 and 2, Former Marine Corps Air Station El Toro, Irvine, California (Trevet 2011)

Italicized results are of field duplicates.

Data qualifiers:

J = The reported concentration is an estimated value.

U = Analyte was not reported at concentration exceeding the indicated value.

[a] Within and in the immediate vicinity of Northern and Southern EOD Training Ranges.

[b] Dissolved oxygen reading by field test kit due to equipment malfunction.

- = not analyzed

bgs = below ground surface

CaCO3 = calcium carbonate

EOD = explosive ordnance disposal

IRP = Installation Restoration Program

mg/L = milligrams per liter

mV = millivolt

ORP = oxygen-reduction potential

pH = negative log of the hydrogen ion concentration

Table 3-3: Summary of Geochemical Data[a] - IRP Sites 1 and 2 Groundwater

Parameter	Average Concentration	Maximum Value	Minimum Value
Within IRP Site 1 Boundary [b]			
Sulfate (mg/L)	54.7	342	8.9
Nitrate (mg/L)	14.0	44.4	3.4
Alkalinity (as $CaCO_3$) (mg/L)	173	223	101
Dissolved Oxygen (mg/L)	3.4	8.0	0.2
ORP (mV)	103	487	-221
pH	7.31	7.99	6.51
Area Between IRP Sites 1 and 2			
Sulfate (mg/L)	134.7	185	92
Nitrate (mg/L)	6.2	10.2	4.1
Alkalinity (as $CaCO_3$) (mg/L)	269	385	225
Dissolved Oxygen (mg/L)	2.1	6.5	0.3
ORP (mV)	88	168	8
pH	7.24	7.44	7.07
IRP Site 2 Area			
Sulfate (mg/L)	217	298	137
Nitrate (mg/L)	8.6	22.3	0.1
Alkalinity (as $CaCO_3$) (mg/L)	337	450	256
Dissolved Oxygen (mg/L)	1.8	5.2	0.1
ORP (mV)	68	170	-16
pH	6.96	7.53	6.29

Notes:

[a]Summary of results presented in Table 3-2.

[b] Within and in the immediate vicinity of Northern and Southern EOD Training Ranges.

Table 5-1: Federal Chemical-Specific[a] ARARs by Medium

Requirement	Prerequisite	Citation[b]	ARAR Determination	Comments
GROUNDWATER				
Safe Drinking Water Act (42 U.S.C., ch. 6A, § 300[f]–300[j]-26)[c]				
National primary drinking water standards are health-based standards for public water systems (MCLs).	Public water system.	40 C.F.R. 141.61(a)	Relevant and Appropriate (for IRP Site 2 groundwater response action only)	MCLs for VOCs reported in groundwater are considered to be relevant and appropriate requirements for IRP Site 2 groundwater that is a potential source of drinking water. Federal MCLs were used to develop remediation goals for COCs in IRP Site 2 groundwater (see Table 5-6).
MCLGs pertain to known or anticipated adverse health effects (also known as recommended MCLs).	Public water system.	40 C.F.R. § 141.50 (b)	Relevant and Appropriate (for IRP Site 2 groundwater response action only)	MCLGs for VOCs reported in groundwater set at levels above zero are considered to be relevant and appropriate requirements for IRP Site 2 groundwater that is a potential source of drinking water (40 C.F.R. § 300.430[e][2][I][B]-[D]). Federal MCLGs were used to develop remediation goals for COCs in IRP Site 2 groundwater (see Table 5-6).
Resource Conservation and Recovery Act (42 U.S.C., ch. 82, §§ 6901–6991[i])[c]				
Defines RCRA hazardous waste. A solid waste is characterized as toxic, based on the TCLP, if the waste exceeds the TCLP maximum concentrations.	Waste.	Cal. Code Regs. tit. 22, § 66261.21, 66261.22(a)(1), 66261.23, 66261.24(a)(1), and 66261.100	Applicable	Applicable for determining whether waste is hazardous. The wastes generated during the remedial actions such as well development or purge water will be evaluated to assess if they meet the definition of RCRA hazardous waste in accordance with these regulations.

Table 5- 1 (continued)

Requirement	Prerequisite	Citation[b]	ARAR Determination	Comments
Groundwater protection standards: Owners/operators of RCRA treatment, storage, or disposal facilities must comply with conditions in this section that are designed to ensure that hazardous constituents entering the groundwater from a regulated unit do not exceed the concentration limits for contaminants of concern set forth under Cal. Code Regs. tit. 22, § 66264.94 in the uppermost aquifer underlying the waste management area of concern at the POC.	A regulated unit that receives or has received hazardous waste before 26 July 1982 or regulated units that ceased receiving hazardous waste prior to 26 July 1982 where constituents in or derived from the waste may pose a threat to human health or the environment.	Cal. Code Regs. tit. 22, § 66264.94, except 66264.94(a)(2) and 66264.94(b)	Relevant and Appropriate	Relevant and appropriate for groundwater monitoring at IRP Sites 1 and 2. The groundwater will be cleaned up to lesser of the federal MCL, federal *non-zero* MCLGs, and California MCL. The remediation goals for the groundwater remedial actions are presented in Table 5-6.
SOIL				
Resource Conservation and Recovery Act (42 U.S.C., ch. 82, §§ 6901–6991[i])[c]				
Defines RCRA hazardous waste. A solid waste is characterized as toxic, based on the TCLP, if the waste exceeds the TCLP maximum concentrations.	Waste.	Cal. Code Regs. tit. 22, § 66261.21, 66261.22(a)(1), 66261.23, 66261.24(a)(1), and 66261.100	Applicable	Applicable for determining whether the soil cuttings generated as a result of well installation at IRP Sites 1 and 2 are hazardous.

Notes:

[a] many action-specific ARARs contain chemical-specific limitations and are addressed in the action-specific ARAR tables

[b] only the substantive provisions of the requirements cited in this table are ARARs

[c] statutes and policies, and their citations, are provided as headings to identify general categories of ARARs for the convenience of the reader; listing the statutes and policies does not indicate that the DON accepts the entire statutes or policies as ARARs; specific ARARs are addressed in the table below each general heading; only pertinent substantive requirements of the specific citations are considered ARARs

Acronyms/Abbreviations:

ARAR – applicable or relevant and appropriate requirement
Cal. Code Regs. – *California Code of Regulations*
C.F.R. – *Code of Federal Regulations*
ch. – chapter
MCL – maximum contaminant level
MCLG – maximum contaminant level goal
POC – point of compliance
RCRA – Resource Conservation and Recovery Act
TCLP – toxicity characteristic leaching procedure
tit. – title
U.S.C. – *United States Code*
§ – section

Table 5-2: Federal Location-Specific ARARs

Location	Requirement	Prerequisite	Citation[a]	ARAR Determination	Comments
Wetland	Avoid, to the extent possible, the adverse impacts associated with the destruction or loss of wetlands and avoid support of new construction in wetlands if practicable alternatives exist.	Wetland meeting definition of Section 7(c) of the Exec. Order No. 11990.	40 C.F.R. § 6.302(a) and 40 C.F.R. pt. 6, app. A, § 6(a)(1), (3), and (5) (at the end of § 6.1007)	Relevant and Appropriate (only for IRP Site 1)	Potential disturbed wetland habitat occurs at the bottom of the Ephemeral pond at IRP Site 1. It consists of a sparse cover of a variety of weedy and wetland species including mulefat, black willow, mustard, tocalote, and soft chess. There is approximately 0.29-acre of disturbed wetland on IRP Site 1. Therefore, substantive provisions of 40 C.F.R. § 6.302 (a) and 40 C.F.R. pt. 6, app. A, § 6(a)(1), (3), and (5) (at the end of § 6.1007) are ARARs for response actions at IRP Site 1. The disturbed wetland habitat is not expected to be adversely impacted by the groundwater remedial action at IRP Site 1. The remedial action activities will not be performed within wetland habitat at the bottom of the Ephemeral pond.

Table 5-2 (continued)

Location	Requirement	Prerequisite	Citation[a]	ARAR Determination	Comments
Exec. Order No. 11988, Floodplain Management[b]					
Within floodplain	Evaluate potential effects of actions in a floodplain to avoid, to the extent possible, adverse effects associated with direct and indirect development of a floodplain.	Action that will occur in a floodplain (i.e., lowlands) and relatively flat areas adjoining inland and coastal waters and other flood-prone areas.	40 C.F.R. § 6.302(b) and 40 C.F.R. pt. 6, app. A, § 6(a)(1), (3), and (5) (at the end of § 6.1007)	Relevant and Appropriate	Areas overlying the IRP Site 1 perchlorate-impacted groundwater in the vicinity of IRP Site 2 landfill and the VOC-impacted groundwater at IRP Site 2 are located within the 100-year floodplain. Therefore, substantive requirements of 40 C.F.R. § 6.302(b) and 40 C.F.R. pt. 6 Appendix A, § 6(a)(1), (3), and (5) (at the end of § 6.1007), are ARARs for IRP Sites 1 and 2 groundwater remedial action. The injection/monitoring wells proposed as part of groundwater remedies for IRP Sites 1 and 2 are not expected to adversely effect the ability of Borrego Canyon Wash, its tributaries, and associated Alton Parkway channel improvements to convey floodwaters.
Clean Water Act of 1977, as Amended, Section 404 (33 U.S.C. § 1344)[b]					
Waters of the United States	Action to prohibit discharge of dredged or fill material into waters of the United States without permit.	Discharge into Waters of the United States.	33 U.S.C. § 1344	Applicable	Discharge of dredged or fill material to waters of the United States is possible as part of the response actions at IRP Sites 1 and 2. Therefore, the substantive requirements of 33 U.S.C. § 1344 are ARARs for the remedial actions at IRP Sites 1 and 2. The evaluation of pertinent action-specific provisions of 40 C.F.R §§ 230.10 (a), (c), and (d); and 33 C.F.R §§ 323.3(a) and (b); and 330.1(b) and (c) are presented in Table 5-3.

Table 5- 2 (continued)

Location	Requirement	Prerequisite	Citation[a]	ARAR Determination	Comments
Resource Conservation and Recovery Act (42 U.S.C. §§ 6901–6991[i])[b]					
Within 100-year floodplain	Facility must be designed, constructed, operated, and maintained to avoid washout.	RCRA hazardous waste; treatment, storage, or disposal of hazardous waste.	Cal. Code Regs. tit. 22, § 66264.18(b)	Relevant and Appropriate (only for IRP Site 1 groundwater response action if groundwater recirculation system is implemented as part of in-situ bioremediation)	Areas overlying the IRP Site 1 perchlorate-impacted groundwater in the vicinity of IRP Site 2 landfill and IRP Site 2 VOC-impacted groundwater are located within the 100- year floodplain. The requirements of Cal. Code Regs. tit. 22, § 66264.18(b) were evaluated to determine if they constitute ARARs for groundwater remedial action. This evaluation indicated that flood plain protection requirements of Cal. Code Regs. tit. 22, §66264.18(b) are ARARs for only IRP Site 1 groundwater response action if groundwater recirculation system is implemented as part of in-situ bioremediation. No long-term recirculation system or permanent treatment facility are proposed as part of IRP Site 1 ISB design in this RD/RA Work Plan. Therefore, this ARAR does not apply to the remedial activities proposed/conducted at this time.

Table 5-2 (continued)

Location	Requirement	Prerequisite	Citation[a]	ARAR Determination	Comments
Endangered Species Act of 1973 (16 U.S.C. §§ 1531–1543)[b]					
Habitat upon which endangered species or threatened species depend	Federal agencies may not jeopardize the continued existence of any listed species or cause the destruction or adverse modification of critical habitat. The Endangered Species Committee may grant an exemption for agency action if reasonable mitigation and enhancement measures such as propagation, transplantation, and habitat acquisition and improvement are implemented.	Determination of effect upon endangered or threatened species or its habitat. Critical habitat upon which endangered species or threatened species depend.	16 U.S.C. § 1536(a), (h)(1)(B); 16 U.S.C. § 1538(a)(1)(B)and (G); and 16 U.S.C. § 1538(a)(2)(B) and (E)	Applicable	IRP Site 1 is located in an area that supports special status species (including the Riverside fairy shrimp and the California gnatcatcher) or habitat. IRP Site 2 is located in an area that supports special status species or habitat and supports one breeding pair of California gnatcatchers. Therefore, the substantive provisions of the Endangered Species Act are ARARs. However, the proposed response actions at IRP Sites 1 and 2 are not anticipated to adversely affect the endangered species, threatened species, or designated critical habitat. Further discussion of compliance with Endangered Species Act and measures proposed to minimize impact to sensitive species and their habitat are presented in Section 8.2.4. In addition, as part of the CERCLA process, the Navy will provide United States Fish and Wildlife Service and/or National Marine Fisheries Service with the opportunity to participate in the routine review of CERCLA documents.

Table 5-2 (continued)

Location	Requirement	Prerequisite	Citation[a]	ARAR Determination	Comments
Migratory Bird Treaty Act of 1972 (16 U.S.C. §§ 703–712)					
Migratory bird area	Protects almost all species of native migratory birds in the U.S. from unregulated "take," which can include poisoning at hazardous waste sites.	Presence of migratory birds.	16 U.S.C. § 703	Relevant and Appropriate	Migratory birds have been observed at IRP Sites 1 and 2; therefore, this is a relevant and appropriate ARAR. A discussion of measures proposed to minimize impacts to birds protected by Migratory Bird Treaty Act are presented in Section 8.2.4.

Notes:

[a] only the substantive provisions of the requirements cited in this table are ARARs

[b] statutes and policies, and their citations, are provided as headings to identify general categories of ARARs for the convenience of the reader; listing the statutes and policies does not indicate that the DON accepts the entire statutes or policies as ARARs; specific ARARs are addressed in the table below each general heading; only substantive requirements of the specific citations are considered ARARs

Acronyms/Abbreviations:

app. – appendix
ARAR – applicable or relevant and appropriate requirement
Cal. Code Regs. – *California Code of Regulations*
C.F.R. – *Code of Federal Regulations*
DON – Department of the Navy
Exec. Order No. – executive order number

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Table 5-3: Federal Action-Specific ARARs

Selected Remedy for Perchlorate-Impacted Groundwater at IRP Site 1: Alternative G1-5: In-Situ Bioremediation at the Source Area, Downgradient of the Source Area and Near the Station Boundary, Monitoring, and ICs

Selected Remedy for VOC-Impacted Groundwater at IRP Site 2: Alternative G2-2: MNA and ICs

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Resource Conservation and Recovery Act (42 U.S.C. §§ 6901–6991[i])*					
On-site waste generation	Person who generates waste shall determine if that waste is a hazardous waste.	Generator of waste.	Cal. Code Regs. tit. 22, § 66262.10(a), 66262.11	Applicable	Applicable for any operation where hazardous waste is generated. The determination of whether groundwater and/or wastes generated during remedial activities, such as soil cutting from well installation and treatment residues, are hazardous will be made at the time the wastes are generated.
On-site waste generation	Requirements for analyzing waste for determining whether waste is hazardous.	Generator of waste.	Cal. Code Regs. tit. 22, § 66264.13(a) and (b)	Applicable	Applicable when analyzing waste generated during the groundwater remedial actions at IRP Sites 1 and 2.
Hazardous waste accumulation	On-site hazardous waste accumulation is allowed for up to 90 days as long as the waste is stored in containers in accordance with § 66262.171–178 or in tanks, on drip pads, inside buildings, is labeled and dated, etc.	Accumulate hazardous waste `	Cal. Code Regs. tit. 22, § 66262.34	Applicable	Applicable for any operation where hazardous waste is generated and transported. The determination of whether wastes generated during response action activities, such as soil cuttings from well installation and treatment residues, are hazardous will be made at the time the wastes are generated.
Container storage	Containers of RCRA hazardous waste must be: • maintained in good condition, • compatible with hazardous waste to be stored, and • closed during storage except to add or remove waste.	Storage of RCRA hazardous waste not meeting small-quantity generator criteria before treatment, disposal, or storage elsewhere, in a container.	Cal. Code Regs. tit. 22, § 66264.171, .172, .173	Applicable	Substantive requirements are applicable for accumulation of waste for less than 90 days if the waste is RCRA hazardous waste and is stored on site in accordance with § 66262.34.

Table 5-3 (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Container storage (continued)	Inspect container storage areas weekly for deterioration.		Cal. Code Regs. tit. 22, § 66264.174	Applicable	Substantive requirements are applicable if hazardous wastes are generated and stored on site for less than 90 days in accordance with § 66262.34.
	Place containers on a sloped, crack-free base, and protect from contact with accumulated liquid. Provide containment system with a capacity of 10 percent of the volume of containers of free liquids. Remove spilled or leaked waste in a timely manner to prevent overflow of the containment system.	Storage in a container of RCRA hazardous waste not meeting small-quantity generator criteria before treatment, disposal, or storage elsewhere.	Cal. Code Regs. tit. 22, § 66264.175(a) and (b)	Applicable	Applicable if hazardous wastes are generated and stored on site for less than 90 days in accordance with § 66262.34.
	Keep incompatible materials separate. Separate incompatible materials stored near each other by a dike or other barrier.		Cal. Code Regs. tit. 22, § 66264.177	Applicable	Applicable for temporary storage of incompatible materials in accordance with § 66262.34.
	At closure, remove all hazardous waste and residues from the containment system, and decontaminate or remove all containers and liners.		Cal. Code Regs. tit. 22, § 66264.178	Applicable	Applicable if RCRA hazardous wastes are generated and stored on site for less than 90 days in accordance with § 66262.34.

Table 5-3 (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Use of tank systems or piping	Requirements for the design and installation of new tank systems including strength, tightness testing, damage control, support, corrosion control, etc. Requirements for secondary containment of tank systems. Requirements for secondary containment of ancillary equipment. Requirements for operation of tank systems including spill prevention and prohibitions of material that could cause failure. Requirements for inspection of tank systems including inspection of overflow protection, corrosion, release, detection equipment, and cathodic protection. Requirements for response to leaks and spills from tank systems including removal of system from use if appropriate, containment, cleanup, emergency procedures, etc. Requirements for closure and postclosure care of tank systems decontamination, clean closure and leaving waste in place at closure.	Tank systems for transferring, storing, or treating hazardous waste.	Cal. Code Regs. tit. 22, §66264.192(a), (b),(c), e),(f), and (g) Cal. Code Regs. tit. 22, §66264.193(b), (c), (d), and (e) Cal. Code Regs. tit. 22, § 66264.193(f) Cal. Code Regs. tit. 22, § 66264.194(a) and (b) Cal. Code Regs. tit. 22, §66264.195(a), (b), and (c) Cal. Code Regs. tit. 22, § 66264.196(b) except (b)(5) and (b)(7) Cal. Code Regs. tit. 22, § 66264.197(a) and (b)	Applicable (for IRP Site 1 response action only if groundwater recirculation system is implemented as part of in-situ bioremediation)	The substantive requirements of the cited regulations are ARARs for IRP Site 1 response action only if the groundwater recirculation system implemented as part of in-situ bioremediation handles hazardous waste. No long-term recirculation system or permanent treatment facility are proposed as part of IRP Site 1 ISB design in this RD/RA Work Plan. Therefore, this ARAR does not apply to the remedial activities proposed/conducted at this time.

Table 5-3 (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Monitoring	Owners/operators of RCRA surface impoundment, waste pile, land treatment unit, or landfill shall conduct a monitoring and response program for each regulated unit.	Surface impoundment, waste pile, land treatment unit, or landfill for which constituents in or derived from waste in the unit may pose a threat to human health or the environment.	Cal. Code Regs. tit. 22, § 66264.91(a)(4)and (c), except as it cross-references permit requirements	Relevant and appropriate	Relevant and appropriate for groundwater monitoring. The design of performance/long-term monitoring for groundwater as part of IRP Sites 1 and 2 groundwater remedies will comply with the substantive provisions of these requirements.
	Requirements for monitoring groundwater, surface water, and the vadose zone.	Hazardous waste treatment, storage, or disposal facility.	Cal. Code Regs. tit. 22, § 66264.97 (b)(1)(A), (b)(1)(D)(1) and (2), (b) (4-7), (e)(6), (12)(A) and (B), (13), and (15)	Relevant and appropriate	Relevant and appropriate for groundwater monitoring. The design of performance/long-term monitoring for groundwater as part of IRP Sites 1 and 2 groundwater remedies will comply with the substantive provisions of these requirements.

Table 5-3 (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
	Requirements for a detection monitoring program.	Hazardous waste treatment, storage, or disposal facility.	Cal. Code Regs. tit. 22, § 66264.98(e) (1-5), (i), (j), (k)(1-3), (4)(A) and (D),(5), (7)(C) and (D),(n)(1),(2) (B), and (C)	Relevant and appropriate	The requirements of detection monitoring program are only relevant and appropriate following completion of corrective action monitoring. Following achievement of remediation goals for groundwater and compliance with substantive requirements of the corrective action monitoring program (accepted as ARARs below), the need for detection monitoring program will be evaluated. If no further groundwater monitoring is required to protect human health or the environment, no further detection monitoring will be conducted. However, if additional groundwater monitoring is required to protect human health or the environment, these requirements will be ARARs for the groundwater monitoring program.
Corrective action	An owner or operator required pursuant to section 66264.91 to establish a corrective action program for a regulated unit shall, at a minimum, comply with the requirements of this section for that unit.	Hazardous waste treatment, storage, or disposal facility.	Cal. Code Regs. tit. 22, § 66264.100(a)	Relevant and appropriate	Relevant and appropriate for groundwater monitoring. The design of performance/long-term monitoring for groundwater as part of IRP Sites 1 and 2 groundwater remedies will comply with the substantive provisions of these requirements.

Table 5-3 (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Corrective action	The owner or operator required to take corrective action under Cal. Code Regs. tit. 22, § 66264.91 shall take corrective action to remediate releases from the regulated unit and to ensure that the regulated unit achieves compliance with the water quality protection standard.	Hazardous waste treatment, storage, or disposal facility.	Cal. Code Regs. tit. 22, § 66264.100(b)	Relevant and appropriate	In accordance with the settlement between the DON and DTSC and the fact that wastes at IRP Site 1 are similar to RCRA hazardous wastes, substantive provisions of cited regulations are "relevant and appropriate" federal ARARs for groundwater remedial action at IRP Site 1. IRP Site 2 is not a RCRA regulated unit, therefore, the requirements are not applicable. However, the requirements are relevant and appropriate for the groundwater remedial action at IRP Site 2.
	The owner or operator shall implement corrective action measures that ensure that constituents of concern achieve their respective concentration limits at all monitoring points and throughout the zone affected by the release, including any portions of the affected zone that extend beyond the facility boundary, by removing the waste constituents or treating them in place. The owner or operator shall take other action to prevent noncompliance due to a continued or subsequent release including, but not limited to, source control.	Hazardous waste treatment, storage, or disposal facility.	Cal. Code Regs. tit. 22, § 66264.100(c)	Relevant and appropriate	In accordance with the resolution between the DON and DTSC and the fact that wastes at IRP Site 1 are similar to RCRA hazardous wastes, substantive provisions of cited regulations are "relevant and appropriate" federal ARARs for groundwater remedial action at IRP Site 1. IRP Site 2 is not a RCRA regulated unit, therefore, the requirements are not applicable. However, the requirements are relevant and appropriate for the groundwater remedial action at IRP Site 2.

Table 5-3 (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Corrective action (continued)	The owner or operator shall establish and implement, in conjunction with the corrective action measures, a water quality monitoring program that will demonstrate the effectiveness of the corrective action program and be effective in determining compliance with the water quality protection standard and in determining the success of the corrective action measures under subsection (c) of this section.	Hazardous waste treatment, storage, or disposal facility.	Cal. Code Regs. tit. 22, § 66264.100(d)	Relevant and appropriate	Relevant and appropriate for groundwater monitoring. The design of performance/long-term monitoring for groundwater as part of IRP Sites 1 and 2 groundwater remedies will comply with the substantive provisions of these requirements.
	The corrective action program is complete when compliance with the water quality standard is demonstrated based on the results of sampling and analysis for all constituents of concern for a period of 1 year.	Hazardous waste treatment, storage, or disposal facility.	Cal. Code Regs. tit. 22, § 66264.100(g)(1)	Relevant and appropriate	Relevant and appropriate for groundwater monitoring. The design of performance/long-term monitoring for groundwater as part of IRP Sites 1 and 2 groundwater remedies will comply with the substantive provisions of these requirements.
Completion of response action	Corrective action measures taken pursuant to this section may be terminated when the owner or operator demonstrates to the satisfaction of the Department that the concentrations of all constituents of concern are reduced to levels below their respective concentration limits.	Hazardous waste treatment, storage, or disposal facility.	Cal. Code Regs. tit. 22, § 66264.100(f)	Relevant and appropriate	Relevant and appropriate for groundwater monitoring. The design of performance/long-term monitoring for groundwater as part of IRP Sites 1 and 2 groundwater remedies will comply with the substantive provisions of these requirements.
Solid Waste Management Unit/Permitted Hazardous Waste Management Unit	Media impacted by RCRA hazardous waste must be considered for corrective action regardless of the date of original impact.	Hazardous waste transfer, treatment, storage, or disposal facility.	Cal. Code Regs. tit. 22, § 66264.101(a)	Relevant and appropriate	Relevant and appropriate for groundwater monitoring. The design of performance/long-term monitoring for groundwater as part of IRP Sites 1 and 2 groundwater remedies will comply with the substantive provisions of these requirements.

Table 5-3 (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Discharge of dredged /fill material	Guidelines for specification of disposal sites for dredged material. The discharge must represent the least damaging, practicable alternative. The discharge of dredged material must not result in significant degradation of the aquatic ecosystem. All practicable means must be utilized to minimize adverse environmental impacts.	Discharge of dredged material to waters of the United States.	40 C.F.R. § 230.10(a), (c), and (d)	Applicable	Remedial actions for IRP Site 1 perchlorate-impacted groundwater and IRP Site 2 VOC-impacted groundwater may lead to discharge of fill material (as defined at 40 C.F.R. § 232.2) into waters of the United States. The discharge of fill material will comply with substantive provisions of the cited regulation by complying with substantive provisions of the Nationwide Permit 38 issued by the U.S. Army Corps of Engineers (see Section 8.2.5 for additional discussion). The CERCLA response actions are not required to obtain permits as provided in 42 U.S.C. § 9621(e).
	Where the proposed discharge and extraction sites are adjacent and are comprised of similar materials and subject to the same sources of contaminants, disposal may be conducted without further testing because discharge is not likely to result in degradation of the discharge site, as long as the potential spread of contaminants to less contaminated areas can be prevented.		40 C.F.R. § 230.60(c)	Applicable	Remedial actions for IRP Site 1 perchlorate-impacted groundwater and IRP Site 2 VOC-impacted groundwater may lead to discharge of fill material (as defined at 40 C.F.R. § 232.2) into waters of the United States. The discharge of fill material will comply with substantive provisions of the cited regulation by complying with substantive provisions of the Nationwide Permit 38 issued by the U.S. Army Corps of Engineers (see Section 8.2.5 for additional discussion). The CERCLA response actions are not required to obtain permits as provided in 42 U.S.C. § 9621(e).

Table 5-3 (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Discharge of dredged /fill material (continued)	The discharge of dredged material may be conducted without further testing if constraints are available to reduce contamination to acceptable levels within the discharge site and to prevent contaminants from being transported beyond the proposed discharge site boundaries.		40 C.F.R. § 230.60(d)	Applicable	Remedial actions for IRP Site 1 perchlorate-impacted groundwater and IRP Site 2 VOC-impacted groundwater may lead to discharge of fill material (as defined at 40 C.F.R. § 232.2) into waters of the United States. The discharge of fill material will comply with substantive provisions of the cited regulation by complying with substantive provisions of the Nationwide Permit 38 issued by the U.S. Army Corps of Engineers (see Section 8.2.5 for additional discussion). The CERCLA response actions are not required to obtain permits as provided in 42 U.S.C. § 9621(e).
	U.S. Army Corps of Engineers requirements for permitting discharges of dredged material to waters of the United States.	Discharge of dredged material to waters of the United States.	33 C.F.R. §§ 323.3(a) and (b); and 330.1(b) and (c)	Applicable	Remedial actions for IRP Site 1 perchlorate-impacted groundwater and IRP Site 2 VOC-impacted groundwater may lead to discharge of fill material (as defined at 40 C.F.R. § 232.2) into waters of the United States. The discharge of fill material will comply with substantive provisions of the cited regulation by complying with substantive provisions of the Nationwide Permit 38 issued by the U.S. Army Corps of Engineers (see Section 8.2.5 for additional discussion). The CERCLA response actions are not required to obtain permits as provided in 42 U.S.C. § 9621(e).

Table 5-3 (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Safe Drinking Water Act (42 U.S.C. § 300[f]–300[j]-26)*					
Injection	The UIC program prohibits injection activities that allow movement of contaminants into underground sources of drinking water that may result in violations of MCLs or adversely affect health.	An approved UIC program is required in states listed under SDWA Section 1422. Class I wells and Class IV wells are the relevant classifications for CERCLA sites. Class I wells are used to inject hazardous waste beneath the lowermost formation that contains a USDW within 0.25 mile of the well.	40 C.F.R. § 144.12, excluding the reporting requirements in § 144.12(b) and 144.12(c)(1)	Relevant and appropriate (only for IRP Site 1)	Injection wells would be Class V wells under the UIC program. There are currently no specific technical requirements for injection into Class V wells. Substantive provisions of the UIC rules are relevant and appropriate for injection of treatment amendments into groundwater proposed as part of the IRP Site 1 groundwater response action. Substrate injection as part of in-situ bioremediation of perchlorate will be conducted within the approximate footprint of the impacted groundwater where perchlorate has been already reported to exceed its MCL. In addition, the overall intent of substrate injection is to reduce perchlorate concentrations below its MCL; therefore, substantive requirements of 40 C.F.R. § 144.12 will be met.

Table 5-3 (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Injection	Injection pressure may not exceed a maximum level designed to ensure that injection does not initiate new fractures or propagate existing ones and cause the movement of fluids into a USDW. Continuously monitor injection pressure, flow rate, and volume, and annual pressure, if required. Demonstration of mechanical integrity is required every 5 years. Groundwater monitoring may also be required.		40 C.F.R. § 146.13(a), (b), (d)	Relevant and appropriate (for IRP Site 1 groundwater response action only if groundwater recirculation system is implemented as part of in-situ bioremediation)	Relevant and appropriate for groundwater reinjection. The substantive requirements of the cited regulations are ARARs for IRP Site 1 groundwater response action only if groundwater recirculation system is implemented as part of in-situ bioremediation. No long-term recirculation system or permanent treatment facility are proposed as part of IRP Site 1 ISB design in this RD/RA Work Plan. Therefore, this ARAR does not apply to the remedial activities proposed/conducted at this time.
	Wastes that no longer exhibit a hazardous characteristic are not prohibited if the wastes are disposed into a nonhazardous or hazardous injection well as defined under 40 C.F.R. § 146.6(a).	Characteristically hazardous wastewaters.	40 C.F.R. § 148.1(d)	Relevant and appropriate (for IRP Site 1 groundwater response action only if groundwater recirculation system is implemented as part of in-situ bioremediation)	Relevant and appropriate for groundwater reinjection. The substantive requirements of the cited regulations are ARARs for IRP Site 1 groundwater response action only if groundwater recirculation system is implemented as part of in-situ bioremediation. No long-term recirculation system or permanent treatment facility are proposed as part of IRP Site 1 ISB design in this RD/RA Work Plan. Therefore, this ARAR does not apply to the remedial activities proposed/conducted at this time.

Table 5-3 (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Resource Conservation and Recovery Act					
Hazardous waste management system	Definitions.		40 C.F.R. § 260.10	Applicable	Applicable for the groundwater remedial action alternatives at IRP Sites 1 and 2.
Federal Hazardous Materials Transportation Law (49 U.S.C. §§ 5101–5127)*					
Transportation of hazardous material	No person shall represent that a container or package is safe unless it meets the requirements of 49 U.S.C. §§ 5101–5127.	Interstate carriers transporting hazardous waste and substances by motor vehicle. Transportation of hazardous material under contract with any department of the executive branch of the federal government.	49 C.F.R. § 171.2(f)	Relevant and appropriate	Substantive requirements are relevant and appropriate for transportation of hazardous materials (if any) on site.
	No person shall unlawfully alter or deface labels, placards or descriptions, packages, containers, or motor vehicles used for transportation of hazardous materials.		49 C.F.R. § 171.2(g)	Relevant and appropriate	Substantive requirements are relevant and appropriate for transportation of hazardous materials (if any) on site.

Table 5-3 (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Hazardous materials marking, labeling, and placarding	Each person who offers hazardous material for transportation or each carrier that transports it shall mark each package, container, and vehicle in the manner required.	Person who offers hazardous material for transportation; carries hazardous material; or packages, labels, or placards hazardous material.	49 C.F.R. § 172.300	Relevant and appropriate	Substantive requirements are relevant and appropriate for transportation of hazardous materials (if any) on site.
	Each person offering nonbulk hazardous materials for transportation shall mark the proper shipping name and identification number (technical name) and consignee's name and address.		49 C.F.R. § 172.301	Relevant and appropriate	Substantive requirements are relevant and appropriate for transportation of hazardous materials (if any) on site.
	Hazardous materials for transportation in bulk packages must be labeled with proper ID number, specified in 49 C.F.R. § 172.101 table, with required size of print. Packages must remain marked until cleaned or refilled with material requiring other marking.		49 C.F.R. § 172.302	Relevant and appropriate	Substantive requirements are relevant and appropriate for transportation of hazardous materials (if any) on site.

Table 5-3 (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Hazardous materials marking, labeling, and placarding (continued)	No package marked with a proper shipping name or ID number may be offered for transport or transported unless the package contains the identified hazardous material or its residue.		49 C.F.R. § 172.303	Relevant and appropriate	Substantive requirements are relevant and appropriate for transportation of hazardous materials (if any) on site.
	The markings must be durable, in English, in contrasting colors, unobscured, and away from other markings.		49 C.F.R. § 172.304	Relevant and appropriate	Substantive requirements are relevant and appropriate for transportation of hazardous materials (if any) on site.
	Nonbulk combination packages containing liquid hazardous materials must be packed with closures upward, and marked with arrows pointing upward.		49 C.F.R. § 172.312	Relevant and appropriate	Substantive requirements are relevant and appropriate for transportation of hazardous materials (if any) on site.
	Labeling of hazardous material packages shall be as specified in the list.		49 C.F.R. § 172.400	Relevant and appropriate	Substantive requirements are relevant and appropriate for transportation of hazardous materials (if any) on site.
	Each bulk packaging or transport vehicle containing any quantity of hazardous material must be placarded on each side and each end with the type of placards listed in Tables 1 and 2 of 49 C.F.R. § 172.504.	Each person who offers for transport or transports any hazardous materials shall comply with these placarding requirements.	49 C.F.R. § 172.504	Relevant and appropriate	Substantive requirements are relevant and appropriate for transportation of hazardous materials (if any) on site.

Note:

* statutes and policies, and their citations, are provided as headings to identify general categories of ARARs for the convenience of the reader. Listing the statutes and policies does not indicate that the DON accepts the entire statutes or policies as ARARs; specific ARARs are addressed in the table below each general heading; only substantive requirements of specific citations are considered ARARs

Acronyms/Abbreviations:
ARAR – applicable or relevant and appropriate requirement
Cal. Code Regs. – *California Code of Regulations*
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
C.F.R. – *Code of Federal Regulations*
DON – Department of the Navy
IR – Installation Restoration (Program)
MCAS – Marine Corps Air Station
RCRA – Resource Conservation and Recovery Act
§ – section
SDWA – Safe Drinking Water Act
tit. – title
UIC – underground injection control
U.S. – United States
U.S.C. – *United States Code*
VOC – volatile organic compound

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Table 5-4: State Chemical-Specific[a] ARARs by Medium

Requirement	Prerequisite	Citation[b]	ARAR Determination	Comments
GROUNDWATER				
Cal/EPA Department of Toxic Substances Control				
Definition of "non-RCRA hazardous waste."	Waste.	Cal. Code Regs. tit. 22, § 66261.3(a)(2)(C) or 66261.3(a)(2)(F), 66261.22(a)(3) and (4), 66261.24(a)(2)–(a)(8), 66261.101(a)(1) and (a)(2)	Applicable	Applicable for determining whether a waste is a non-RCRA hazardous waste. The wastes generated during the remedial actions such as well development or purge water will be evaluated to assess if they meet the definition of RCRA hazardous waste in accordance with these regulations.
State MCL list (Organics).	Source of drinking water.	Cal. Code Regs. tit. 22, § 64444	Relevant and Appropriate (for IRP Site 2 groundwater response action only)	Like federal MCLs, these are tap water standards and are relevant and appropriate since aquifer underlying IRP Site 2 is a Class II aquifer. State MCLs were used to develop remediation goals for COCs in IRP Site 2 groundwater (see Table 5-6).
State MCL list (Inorganics).	Source of drinking water.	Cal. Code Regs. tit. 22, § 64431 (Perchlorate MCL of 6 µg/L)	Relevant and Appropriate (for IRP Site 1 groundwater response action only)	Like federal MCLs, these are tap water standards and are relevant and appropriate since aquifer underlying IRP Site 1 is a Class II aquifer. State MCLs were used to develop remediation goals for perchlorate in IRP Site 1 groundwater (see Table 5-6).

Table 5-4 (continued)

Requirement	Prerequisite	Citation[b]	ARAR Determination	Comments
Describes the water basins in Santa Ana Region, establishes beneficial uses of groundwater and surface water, establishes WQOs, including narrative and numerical standards, establishes implementation plans to meet WQOs and protect beneficial uses, and incorporates statewide water quality control plans and policies.		Comprehensive Water Quality Control Plan for the Santa Ana Region (Basin Plan) (Cal. Water Code § 13240)	Relevant and Appropriate	Substantive requirements pertaining to beneficial uses, WQOs, and certain statewide water quality control plans are state ARARs for the surface water and groundwater components of this response action.
Authorizes the SWRCB and RWQCB to establish in water quality control plans beneficial uses and numerical and narrative standards to protect both surface water and groundwater quality. Authorizes regional water boards to issue permits for discharges to land or surface or groundwater that could affect water quality, including NPDES permits, and to take enforcement action to protect water quality.		Cal. Water Code, div. 7, §§ 13241, 13243, 13263(a), 13269 (Identified for IRP Sites 1 and 2), and 13360 (Identified for IRP Site 2 only) (Porter-Cologne Act)	Applicable	The DON accepts the substantive provisions of §§ 13241, 13243, 13263(a), 13269, and 13360 of the Porter-Cologne Act enabling legislation, as implemented through the beneficial uses, WQOs, waste discharge requirements, promulgated policies of the Basin Plan for the Santa Ana Region, as ARARs.
Incorporated into all regional board basin plans. Designates all groundwater and surface waters of the state as drinking water except where the TDS is greater than 3,000 ppm, the well yield is less than 200 gpd from a single well, the water is a geothermal resource or in a water conveyance facility, or the water cannot reasonably be treated for domestic use using either best management practices or best		SWRCB Res. 88-63 (Sources of Drinking Water Policy) and Regional Board Resolution 89-42	Applicable	Substantive requirements are ARARs. The aquifer underlying IRP Sites 1 and 2 does not meet the exclusion criteria specified in the Res. 88-63, and therefore is a potential drinking water source.

Table 5-4 (continued)

Requirement	Prerequisite	Citation[b]	ARAR Determination	Comments
economically achievable treatment practices.				
Definitions of designated waste, nonhazardous waste, and inert waste.		Cal. Code Regs. tit. 27, §§ 20210, 20220, and 20230	Applicable	Applicable for classifying waste and determining ARAR status of other requirements.
Dischargers shall be responsible for accurate characterization of wastes, including determinations of whether or not wastes will be compatible with containment features and other wastes at a Unit, and whether or not wastes are required to be managed as hazardous wastes under Chapter 11 of Division 4.5 of Title 22 of this code.		Cal. Code Regs. tit. 27, §§ 20200(c)	Applicable (for IRP Site 1 groundwater response action only)	Applicable for accurate characterization of wastes.

Notes:

[a] many action-specific ARARs contain chemical-specific limitations and are addressed in the action-specific ARAR tables

[b] only the substantive provisions of the requirements cited in this table are ARARs

[c] statutes and policies, and their citations, are provided as headings to identify general categories of ARARs for the convenience of the reader; listing the statutes and policies does not indicate that the DON accepts the entire statutes or policies as ARARs; specific ARARs are addressed in the table below each general heading; only pertinent substantive requirements of specific citations are considered ARARs

Acronyms/Abbreviations:

ARAR – applicable or relevant and appropriate requirement
Cal. Code Regs. – *California Code of Regulations*
Cal/EPA – California Environmental Protection Agency
Cal. Water Code – *California Water Code*
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
C.F.R. – *Code of Federal Regulations*
div. – division
DON – Department of the Navy
gpd – gallons per day
MCL – maximum contaminant level
NPDES – National Pollutant Discharge Elimination System
Porter-Cologne Act – Porter-Cologne Water Quality Control Act
ppm – parts per million
RCRA – Resource Conservation and Recovery Act
§ – section
SWRCB – (California) State Water Resources Control Board
TDS – total dissolved solids

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Table 5-5: State Action-Specific ARARs

Selected Remedy for Perchlorate-Impacted Groundwater at IRP Site 1: Alternative G1-5: In-Situ Bioremediation at the Source Area, Downgradient of the Source Area and Near the Station Boundary, Monitoring, and ICs

Selected Remedy for VOC-Impacted Groundwater at IRP Site 2: Alternative G2-2: MNA and ICs

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
State Water Resources Control Board and Regional Water Quality Control Board*					
Discharges to high-quality waters	Incorporated into all Regional Board Basin Plans. Requires that quality of waters of the state that is better than needed to protect all beneficial uses be maintained unless certain findings are made. Discharges to high quality waters must be treated using best practicable treatment or control necessary to prevent pollution or nuisance and to maintain the highest quality water. Requires cleanup to background water quality or to lowest concentrations technically and economically feasible to achieve. Beneficial uses must, at least, be protected.		SWRCB Res. 68-16 (Policy With Respect to Maintaining High Quality of Waters in California) (Cal. Water Code § 13140, CWA regulations 40 C.F.R. § 131.12)	Relevant and appropriate (for IRP Site 1 groundwater response action only if groundwater recirculation system is implemented as part of in-situ bioremediation)	SWRCB Res. 68-16 is an ARAR for reinjection only. The DON has determined that perchlorate migration in groundwater at IRP Site 1 is not a discharge governed by the language in SWRCB Res. 68-16. The groundwater remedial alternative will comply by extracting and treating of groundwater from the low COC concentration portion of the aquifer and injecting it into high concentration portion of the aquifer with similar total dissolved solids and nitrate concentrations. The state does not agree with the DON position regarding the ARAR status. The substantive requirements of the cited regulations are ARARs for IRP Site 1 groundwater response action only if groundwater recirculation system is implemented as part of in-situ bioremediation. No long-term recirculation system or permanent treatment facility are proposed as part of IRP Site 1 ISB design in this RD/RA Work Plan. Therefore, this ARAR does not apply to the remedial activities proposed/conducted at this time.

Table 5-5 (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Cal/EPA Department of Toxic Substances Control*					
Land Use Covenants	A land use covenant imposing appropriate limitations on land use shall be executed and recorded when Facility closure, corrective action, remedial or removal action, or other response actions are undertaken and Hazardous materials, hazardous wastes or constituents, or hazardous substances will remain at the property at levels which are not suitable for unrestricted use of the land.	Property transfer by federal government to non-federal entity.	Cal. Code Regs. tit. 22, § 67391.1(a) and (e)(1)	Relevant and appropriate	These requirements are ARARs in the event of the transfer of the IRP Sites 1 and 2 property to a non-federal entity. Cal. Code Regs. tit. 22, § 67391.1 provides for a land-use covenant to be executed and recorded when remedial actions are taken and hazardous substances will remain at the property at concentrations that are unsuitable for unrestricted use of the land. The substantive provisions of this regulation have been determined to be "relevant and appropriate" state ARARs by the DON.
California Civil Code*					
Land-use controls	Provides conditions under which landuse restrictions will apply to successive owners of land.	Transfer property from the DON to a nonfederal agency.	Cal. Civ. Code § 1471	Relevant and appropriate	These requirements are ARARs in the event of the transfer of the IRP Sites 1 and 2 property to a non-federal entity. Generally, Cal. Civ. Code § 1471 allows an owner of land to make a covenant to restrict the use of land for the benefit of a covenantee. The covenant runs with the land to bind successive owners, and the restrictions must be reasonably necessary to protect present or future human health or safety or the environment as a result of the presence on the land of hazardous materials, as defined in Cal. Health & Safety Code § 25260.

Table 5-5 (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
					Substantive provisions are the following general narrative standard: "to do or refrain from doing some act on his or her own (land . . . where (c) Each such act relates to the use of land and each such act is reasonably necessary to protect present or future human health or safety or the environment as a result of the presence of hazardous materials, as defined in Section 25260 of the California Health and Safety Code." This narrative standard would be implemented through incorporation of restrictive covenants in the deed and Environmental Restriction and Covenant Agreement at the time of transfer.
Land-use controls (continued)	Allows DTSC to enter into an agreement with the owner of a hazardous waste facility to restrict present and future land uses.	Transfer property from the DON to a nonfederal agency.	Cal. Health & Safety Code § 25202.5	Relevant and Appropriate	These requirements are ARARs in the event of the transfer of IRP Sites 1 and 2 property to a non-federal entity. The substantive provisions of Cal. Health & Safety Code § 25202.5 are the general narrative standards to restrict "present and future uses of all or part of the land on which the . . . facility . . . is located . . ."

Table 5-5 (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Land-use controls (continued)	Provides a streamlined process to be used to enter into an agreement to restrict specific use of property in order to implement the substantive use restrictions of Cal. Health & Safety Code § 25232(b)(1)(A)–(E).	Transfer property from the DON to a nonfederal agency.	Cal. Health & Safety Code §§ 25222.1 and 25355.5(a)(1)(C)	Relevant and Appropriate	These requirements are ARARs in the event of the transfer of IRP Sites 1 and 2 property to a non-federal entity. Generally, Cal. Health & Safety Code §§ 25222.1 and 25355.5(a)(1)(C) provide the authority for the DTSC to enter into voluntary agreements with land owners to restrict the use of property. The agreements run with the land restricting present and future uses of the land. The substantive requirements of the following Cal. Health & Safety Code § 25222.1 provisions are "relevant and appropriate": (1) the general narrative standard: "restricting specified uses of the property…" and (2) "…the agreement is irrevocable, and shall be recorded by the owner, …as a hazardous waste easement, covenant, restriction or servitude, or any combination thereof, as appropriate, upon the present and future uses of the land." The substantive requirements of the following Cal. Health & Safety Code § 25355.5(a)(1)(C) provisions are "relevant and appropriate": "…execution and recording of a written instrument that imposes an easement, covenant, restriction, or servitude, or combination thereof , as appropriate, upon the present and future uses of the land."

Table 5-5 (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination	Comments
Land-use controls (continued)	Provides processes and criteria for obtaining written variances from a landuse restriction and for removal of the land use restrictions.	Transfer property from the DON to a nonfederal agency.	Cal. Health & Safety Code §§ 25233(c) and 25234	Relevant and Appropriate	These requirements are ARARs in the event of the transfer of IRP Sites 1 and 2 property to a non-federal entity. Cal. Health & Safety Code § 25233(c) sets forth "relevant and appropriate" substantive criteria for granting variances based upon specified environmental and health criteria. Cal. Health & Safety Code § 25234 sets forth the following "relevant and appropriate" substantive criteria for the removal of a land-use restriction on the grounds that "…the waste no longer creates a significant existing or potential hazard to present or future public health or safety."
Air Emission	T-BACT must be employed for new stationary equipment when the operation of that equipment results in a higher than allowable maximum individual cancer risk.	Stationary source that emits carcinogenic air contaminants.	SCAQMD Rule 1401	Applicable (for IRP Site 1 groundwater response action only if groundwater recirculation system is implemented as a remedy	Requires that applicant demonstrate that the cumulative impact of emissions from new or modified source and all other permitted units within 100 meters owned or operated by the applicant are below a maximum individual cancer risk of 10^{-6}. T-BACT is required if maximum individual cancer risk exceeds this limit. VGAC will be designed to achieve maximum individual cancer risk of less than 10^{-6} threshold. No long-term recirculation system or permanent treatment facility are proposed as part of IRP Site 1 ISB design in this RD/RA Work Plan. Therefore, this ARAR does not apply to the remedial activities proposed/conducted at this time.

Notes:

* statutes and policies, and their citations, are provided as headings to identify general categories of ARARs for the convenience of the reader; listing the statutes and policies does not indicate that the DON accepts the entire statutes or policies as ARARs; specific ARARs are addressed in the table below each general heading; only substantive requirements of the specific actions are considered ARARs.

Acronyms/Abbreviations:

ARAR – applicable or relevant and appropriate requirement
Cal. Code Regs. – *California Code of Regulations*
Cal/EPA – California Environmental Protection Agency
Cal. Health & Safety Code – *California Health and Safety Code*
Cal. Water Code – *California Water Code*
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
C.F.R. – *Code of Federal Regulations*
CWA – Clean Water Act
DON – Department of the Navy
DTSC – (Cal/EPA) Department of Toxic Substances Control
NAWQC – National Ambient Water Quality Control
Res. – resolution
§ – section
SCAQMD – South Coast Air Quality Management District
SWRCB – (California) State Water Resources Control Board
T-BACT – best available control technology for toxics
tit. – title
VOC – volatile organic compound

Table 5-6 Remediation Goals – IRP Sites 1 and 2 Groundwater

COC	Selected RG (μg/L)[a]
IRP Site 1	
Perchlorate	6
IRP Site 2	
TCE	5
PCE	5
cis-1,2-DCE	6
1,2-DCA	0.5
1,1,2-TCA	3

Note:
[a] The most stringent of the following values: Federal MCL, non-zero Federal MCLG, and the State of California MCL.

μg/L micrograms per liter
COC chemical of concern
DCA dichloroethane
DCE dichloroethene
IRP Installation Restoration Program
PCE tetrachloroethene
RG remediation goal
TCA trichloroethane
TCE trichloroethene

Table 6-1: Summary of Major Geological/Hydrogeological Parameters used in the ISB Design

Parameter	Source Area	Intermediate Area	Former Station Boundary Area
Hydraulic Conductivity (feet/day)	0.85 [a] (Zone 1) 0.028 [a] (Zone 2)	2.84 [b]	0.24 [a]
Total Porosity	0.34 [b] (Zones 1 and 2)	0.42 [b]	0.35 [b]
Effective Porosity	0.27 [b] (Zones 1 and 2)	0.25 [b]	0.12 [b]
Average Groundwater Flow Velocity (feet/year)	58 (Zone 1) 4 (Zone 2)	50	41

Notes:
[a] Site-specific values based on pump tests; see Section 3.1.1 for details
[b] Literature-based value based on type of soil (McWorter and Sunada, 1977)..

Table 6-2: Design Target ROIs and Well Spacing for PRBs

PRB	Design Target ROI	Injection Point Spacing
Source Area PRB	7.5[a]	15
Intermediate Area PRB	7.5[b]	15
Station Boundary PRB	15[c]	30

Notes:

[a] Conservative estimate based on the 2009-2010 ISB pilot study results considering that hydraulically-enhanced substrate injection strategy will be used. The value is an approximate average of the observed ROIs cross-gradient (5 feet) and downgradient (12 feet) of the injection well for regular pressurized injection (without fracturing).

[b] No pilot study was conducted in the intermediate area. The target ROI is an estimated value based on local geology in the area and ROIs observed during 2009-2010 ISB pilot study.

[c] Conservative estimate based on the 2009-2010 ISB pilot study results considering that hydraulically-enhanced substrate injection strategy will be used. The value is an approximate average of the observed ROIs cross-gradient (5 feet) and downgradient (24 feet) of the injection well for regular pressurized injection (without fracturing).

PRB permeable reactive barrier

ROI radius of influence

Table 6-3: Screen Intervals of Injection/Monitoring Wells – Perchlorate Source Area PRB

Well ID	Existing / Proposed	Primary Purpose of Well		Screened Interval (feet bgs)*
		Substrate Injection	Performance Monitoring	
01-IW01	Existing	✓		41 – 44
01-IW03	Proposed	✓		40 – 50
01-IW04	Proposed	✓		40 – 50
01-MW205	Existing		✓	23 – 57
01-MW225A	Existing		✓	25 – 45
01-MW225B	Existing		✓	47 – 50
01-MW226	Existing		✓	25 – 45
01-MW229	Proposed		✓	40 – 50
01-MW230	Proposed		✓	40 – 50
01-PZ21A	Existing		✓	21 – 46
01-PZ21B	Existing		✓	55 – 65

Note:
Well screen placements and lengths may be modified during field implementation activities based on field observations including depth of alluvium/bedrock contact and groundwater.

bgs below ground surface
ID identification
PRB permeable reactive barrier

Table 6-4: Substrate Loading Summary

ISB Area	Type of Substrate	Total Weight of Substrate (pounds)	Total Volume of Concentrated Substrate (gallons)
Source Area PRB	EDS-ER	688[a]	92
Source Area Direct Injection	HFCS	27,977[b]	2,464[b]
Intermediate Area	EDS-ER	4,080[a]	541
Former Station Boundary Area	EDS-ER	5,712[a]	758

Notes:
[a] Calculated based on the stoichiometric demand using the ESTCP spreadsheet-based Substrate Estimating Tool (ESTCP 2010) (see Appendix B) and assuming EDS-ER is 90 percent oil by weight.
[b] Includes 27,382 pounds (2,410 gallons) required for ISB within Zone 1, and 615 pounds (54 gallons) required for ISB at Zone 2 and upgradient of Zone 1.
EDS-ER Electron Donor Substrate-Extended Release
HFCS high-fructose corn syrup
ISB in situ bioremediation
PRB permeable reactive barrier

Table 6-5: Summary of Substrate Injection Strategy – Perchlorate Source Area PRB

Injection Wells	Extraction Wells	Dilution Ratio of Substrate with Water (by volume)	Number of Parts of Chase Water Injected Per 1 Part of Dilute Substrate	Volume of Dilute EDS-ER + Water (gallons)	Total Volume of Chase Water (gallons)
Phase I					
01-IW01 01-MW225B	01-IW03 01-IW04	5:1	10	153 (76.5)[a]	1533 (766.5)[a]
Phase II					
01-IW03 01-IW04	01-IW01 01-MW225B	5:1	10	306 (153)[a]	3,066 (1,533)[a]

Notes:
[a] Total volume in all injection wells during subject injection phase (Volume in each injection well during subject injection phase). The extracted groundwater supplemented with hydrant water will be used as dilution water for substrate injection. The extracted groundwater will *not* be used as chase water; all chase water will be hydrant water.
EDS-ER Electron Donor Substrate-Extended Release
PRB permeable reactive barrier

Table 6-6: Screen Intervals of Injection/Extraction Wells – Active Source Area Treatment

Well ID	Existing/ Proposed	Screened Interval (feet bgs)*
Zone 1		
01-EW04	Existing	25 – 60
01-EW05	Existing	20 – 60
01-EW06	Existing	35 – 70
01-EW07	Proposed	50 – 70
01-EW08	Proposed	55 – 75
01-EW09	Proposed	50 – 70
01-EW10	Proposed	45 – 65
01-EW11	Proposed	40 – 60
01-IW05	Proposed	50 – 70
01-IW06	Proposed	50 – 70
01-IW07	Proposed	40 – 60
01-IW08	Proposed	40 – 60
01-IW09	Proposed	45 – 65
01-IW10	Proposed	40 – 60
01-IW11	Proposed	40 – 60
01-IW12	Proposed	45 – 65
01-IW13	Proposed	45 – 65
01-MW201	Existing	27 – 57
01-MW219	Existing	40 – 55
01-PZ09	Existing	30 – 55
01-PZ11	Existing	35 – 60
Zone 2 and Upgradient of Zone 1		
01-MW202	Existing	10 – 35
01-MW203	Existing	32 – 57
01-PZ03	Existing	30 – 55
01-PZ08	Existing	55 – 80
01-PZ20	Existing	40 – 70
01-IW14	Proposed	45 - 65

Note:
* Well screen placements and lengths may be modified during field implementation activities based on field observations including depth of alluvium/bedrock contact and groundwater.

bgs below ground surface
ID identification

Table 6-7: Summary of Substrate Injection Strategy – Active Source Area Treatment

Injection Wells	Extraction Wells	Dilution Ratio of Substrate with Water (by volume)	Volume of Dilute HFCS + Water (gallons)
Zone 1 – Phase I			
01-EW06, 01-IW05, 01-IW06, 01-IW07, 01-IW08, 01-IW09, 01-IW10, 01-IW11, 01-IW12, 01-IW13, 01-PZ09, 01-PZ11	01-EW02B, 01-EW04, 01-EW05, 01-EW07, 01-EW08, 01-EW09, 01-EW10, 01-EW11, 01-MW219	10:1	13,764 (1,147)[a]
Zone 1 – Phase II			
01-EW02B, 01-EW04, 01-EW05, 01-EW07, 01-EW08, 01-EW09, 01-EW10, 01-EW11, 01-MW219	Not Applicable	10:1	10,323 (1,147)[a]
Zone 2 and Upgradient of Zone 1			
01-PZ20, 01-PZ08, 01-MW203, 01-MW202, 01-PZ03, 01-IW14	Not Applicable	10:1	648 (108)[a]

Notes:
[a] Total volume in all the listed injection wells (Volume in each injection well).
HFCS high-fructose corn syrup

Table 6-8: Injection/Screen Intervals of Injection/Monitoring Wells – Intermediate Area PRB

Well ID	Existing/ Proposed	Primary Purpose of Well		Injection/Screened Interval (feet bgs)
		Substrate Injection	Performance Monitoring	
01-DPT01	Proposed	✓		25 – 45
01-DPT02	Proposed	✓		25 – 45
01-DPT03	Proposed	✓		25 – 45
01-DPT04	Proposed	✓		25 – 45
01-DPT05	Proposed	✓		25 – 45
01-DPT06	Proposed	✓		25 – 45
01-DPT07	Proposed	✓		25 – 45
01-DPT08	Proposed	✓		35 – 55
01-DPT09	Proposed	✓		35 – 55
01-DPT10	Proposed	✓		35 – 55
01-MW214	Existing		✓	33 – 48
01-MW231	Proposed	✓	✓	35 – 55
01-MW232	Proposed		✓	25 – 45
01-MW233	Proposed		✓	35 – 55
01-MW234	Proposed		✓	35 – 55
01-PZ15	Existing		✓	15 – 40

Note:
* Well screen placements and lengths may be modified during field implementation activities based on field observations including depth of alluvium/bedrock contact and groundwater.

bgs below ground surface
ID identification
PRB permeable reactive barrier

Table 6-9: Summary of Substrate Injection Strategy – Intermediate Area PRB

Injection Points	Dilution Ratio of Substrate with Water (by volume)	Number of Parts of Chase Water Injected Per 1 Part of Dilute Substrate	Volume of Dilute EDS-ER + Water (gallons)	Total Volume of Chase Water (gallons)
01-DPT01, 01-DPT02, 01-DPT03, 01-DPT04, 01-DPT05, 01-DPT06, 01-DPT07, 01-DPT08, 01-DPT09, 01-DPT10, 01-MW231	5:1	10	2,706 (246)[a]	2,7059 (2,459)[a]

Notes:

[a] Total volume in all injection points (Volume in each injection point). The extracted groundwater supplemented with hydrant water will be used as dilution water for substrate injection. The extracted groundwater will *not* be used as chase water; all chase water will be hydrant water.

EDS-ER Electron Donor Substrate – Extended Release

PRB permeable reactive barrier

Table 6-10: Screen Intervals of Injection/Monitoring Wells – Station Boundary PRB

Well ID	Existing or Proposed?	Primary Purpose of Well		Screened Interval (feet bgs)*
		Substrate Injection	Performance Monitoring	
02-IW02	Proposed	✓		65 – 95
02-IW03	Proposed	✓		65 – 95
02-IW04	Proposed	✓		65 – 95
02-IW05	Proposed	✓		65 – 95
02-IW06	Proposed	✓		65 – 95
02-IW07	Proposed	✓		65 – 95
02-IW08	Proposed	✓		65 – 95
02NEW30	Existing		✓	64 – 84
02-NEW36	Proposed		✓	65 – 95
02-NEW37	Proposed		✓	65 – 95
02-NEW38	Proposed		✓	65 – 95
02-NEW39	Proposed		✓	65 – 95
02-NEW40	Proposed		✓	65 – 95
02PZ12	Existing		✓	70 -100

Notes:
* Well screen placements and lengths may be modified during field implementation activities based on field observations including depth of alluvium/bedrock contact and groundwater.

bgs below ground surface
ID identification
PRB permeable reactive barrier

Table 6-11: Summary of Substrate Injection Strategy – Station Boundary PRB

Injection Wells	Extraction Wells	Dilution Ratio of Substrate with Water (by volume)	Number of Parts of Chase Water Injected Per 1 Part of Dilute Substrate	Volume of Dilute EDS-ER + Water (gallons)	Total Volume of Chase Water (gallons)
Phase I					
02-IW02	02-IW03	5:1	10	2,164 (541)[a]	21,656(5,414)[a]
02-IW04	02-IW05				
02-IW06	02-IW07				
02-IW08					
Phase II					
02-IW03	02-IW02	5:1	10	1,623 (541)[a]	16,242 (5,414)[a]
02-IW05	02-IW04				
02-IW07	02-IW06				
	02-IW08				

Notes:
[a] Total volume in all injection wells during subject injection phase (Volume in each injection well during subject injection phase). The extracted groundwater supplemented with hydrant water will be used as dilution water for substrate injection. The extracted groundwater will *not* be used as chase water; all chase water will be hydrant water.
EDS-ER Electron Donor Substrate – Extended Release
PRB permeable reactive barrier

Table 6-12: Baseline Groundwater Monitoring Plan – IRP Site 1 Groundwater

Area	Monitoring Locations	Proposed Analyses											
		Perchlorate	VOCs[a]	DO	ORP	pH	Alkalinity	Anions[b]	Methane	Ethene	Ethane	Bromide	TOC
Source Area	01-EW05	✓		✓	✓	✓							
	01-EW07	✓		✓	✓	✓							
	01-EW09	✓		✓	✓	✓							
	01-IW05	✓		✓	✓	✓							
	01-IW06	✓		✓	✓	✓	✓	✓	✓			✓	✓
	01-IW07	✓		✓	✓	✓	✓	✓	✓			✓	✓
	01-IW09	✓		✓	✓	✓							
	01-IW10	✓		✓	✓	✓							
	01-IW14	✓		✓	✓	✓							
	01-PZ21B	✓		✓	✓	✓							
Source Area PRB	01-IW03	✓		✓	✓	✓							
	01-IW04	✓		✓	✓	✓							
	01-MW205	✓		✓	✓	✓							
Between Source Area and Intermediate PRBs	01-DGMW57	✓		✓	✓	✓							
	01-MW207	✓		✓	✓	✓							
	01-MW217	✓		✓	✓	✓							
	01-PZ14	✓		✓	✓	✓							
	18BGMW24	✓		✓	✓	✓							
Intermediate PRB	01-DPT01[c]	✓		✓	✓	✓							
	01-DPT02[c]	✓		✓	✓	✓							
	01-DPT09[c]	✓		✓	✓	✓							
	01-DPT10[c]	✓		✓	✓	✓							
	01-MW233	✓		✓	✓	✓	✓	✓	✓			✓	✓
Between Intermediate and Station Boundary PRBs	02-NEW16	✓		✓	✓	✓							
Station Boundary PRB	02-IW05	✓	✓	✓	✓	✓							
	02-IW08	✓		✓	✓	✓							
	02-NEW38	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes:

[a] VOCs include TCE, PCE, cis-1,2-DCE, 1,2-DCA, 1,1,2-TCA, and VC.

[b] Anions include nitrate and sulfate.

[c] Hydropunch samples

✓ Indicates that sample will be collected and analyzed for the listed analyte.

Table 6-13: ISB Performance Monitoring Plan – Source Area PRB

Monitoring Locations	Primary Rationale for Well Selection	Proposed Analyses																																					
		First Month (Single Event)[a]										Year 1 (Quarterly)										Years 2 and 3 (Semi-Annually)										After Year 3 (Annually)								
		Perchlorate	DO	ORP	pH	Alkalinity	Anions[b]	Methane	Bromide	TOC	Dissolved Metals	Perchlorate	DO	ORP	pH	Alkalinity	Anions[b]	Methane	Bromide	TOC	Dissolved Metals	Perchlorate	DO	ORP	pH	Alkalinity	Anions[b]	Methane	TOC	Dissolved Metals	Perchlorate	DO	ORP	pH	Alkalinity	Anions[b]	Methane	TOC	Dissolved Metals
01-IW01	Performance data within the PRB		✓	✓	✓				✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	
01-MW225A	Upgradient well for monitoring influent concentrations		✓	✓	✓				✓	✓		✓	✓	✓	✓							✓	✓	✓	✓						✓	✓	✓	✓					
01-MW225B	Upgradient well for monitoring influent concentrations		✓	✓	✓				✓	✓		✓	✓	✓	✓							✓	✓	✓	✓						✓	✓	✓	✓					
01-MW229	Performance data within the PRB; assessment of injection zone of influence		✓	✓	✓				✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓	
01-MW230	Downgradient well to monitor effluent concentrations and PRB effectiveness		✓	✓	✓				✓	✓		✓	✓	✓	✓				✓			✓	✓	✓	✓						✓	✓	✓	✓					
01-PZ21A	Downgradient well to monitor effluent concentrations and PRB effectiveness		✓	✓	✓				✓	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓	✓	✓					✓	✓	✓	✓	✓					✓

Notes:

[a] To be conducted within 15 to 30 days of the completion of substrate injection.

[b] Anions include nitrate and sulfate.

✓ Indicates that sample will be collected and analyzed for the listed analyte.

Table 6-14: ISB Performance Monitoring Plan – Source Area Treatment

Monitoring Locations	Primary Rationale for Well Selection	Proposed Analyses																																				
		First Month (Single Event)[a]									Year 1 (Quarterly)									Years 2 and 3 (Semi-Annually)								After Year 3 (Annually)							
		Perchlorate	DO	ORP	pH	Alkalinity	Anions[b]	Methane	Bromide	TOC	Perchlorate	DO	ORP	pH	Alkalinity	Anions[b]	Methane	Bromide	TOC	Perchlorate	DO	ORP	pH	Alkalinity	Anions[b]	Methane	TOC	Perchlorate	DO	ORP	pH	Alkalinity	Anions[b]	Methane	TOC
Zone 1																																						
01-EW05	Performance data for extraction well within Zone 1		✓	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
01-EW07	Performance data for extraction well within Zone 1		✓	✓	✓				✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓		✓		✓
01-IW10	Performance data for injection well within Zone 1		✓	✓	✓				✓	✓	✓	✓	✓	✓						✓	✓	✓	✓					✓	✓	✓	✓				
01-MW209	Performance data near extraction well 01-EW02B within Zone 1		✓	✓	✓				✓	✓	✓	✓	✓	✓						✓	✓	✓	✓					✓	✓	✓	✓				
01-MW219	Performance data for extraction well within Zone 1		✓	✓	✓				✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓		✓		✓
01-PZ07	Performance data near extraction well 01-EW04 within Zone 1		✓	✓	✓				✓	✓	✓	✓	✓	✓						✓	✓	✓	✓					✓	✓	✓	✓				
01-PZ09	Performance data for injection well within Zone 1		✓	✓	✓				✓	✓	✓	✓	✓	✓						✓	✓	✓	✓					✓	✓	✓	✓				
01-PZ11	Performance data for injection well within Zone 1		✓	✓	✓				✓	✓	✓	✓	✓	✓						✓	✓	✓	✓					✓	✓	✓	✓				
Zone 2 and Upgradient of Zone 1																																						
01-IW14	Performance data for injection well within Zone 2		✓	✓	✓				✓	✓	✓	✓	✓	✓						✓	✓	✓	✓					✓	✓	✓	✓				
01-MW202	Performance data for injection well upgradient of Zone 1		✓	✓	✓				✓	✓	✓	✓	✓	✓						✓	✓	✓	✓					✓	✓	✓	✓				
01-MW203	Performance data for injection well upgradient of Zone 1		✓	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓
01-PZ03	Performance data for injection well upgradient of Zone 1		✓	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓
01-PZ08	Performance data for injection well within Zone 2		✓	✓	✓				✓	✓	✓	✓	✓	✓						✓	✓	✓	✓					✓	✓	✓	✓				
01-PZ20	Performance data for injection well within Zone 2		✓	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes:

[a] To be conducted within 15 to 30 days of the completion of substrate injection.

[b] Anions include nitrate and sulfate.

✓ Indicates that sample will be collected and analyzed for the listed analyte.

Table 6-15: ISB Performance Monitoring Plan – Intermediate Area PRB

Monitoring Locations	Primary Rationale for Well Selection	Proposed Analyses																																							
		First Month (Single Event)[a]										Year 1 (Quarterly)										Years 2 and 3 (Semi-Annually)										After Year 3 (Annually)									
		Perchlorate	DO	ORP	pH	Alkalinity	Anions[b]	Methane	Bromide	TOC	Dissolved Metals	Perchlorate	DO	ORP	pH	Alkalinity	Anions[b]	Methane	Bromide	TOC	Dissolved Metals	Perchlorate	DO	ORP	pH	Alkalinity	Anions[b]	Methane	TOC	Dissolved Metals	Perchlorate	DO	ORP	pH	Alkalinity	Anions[b]	Methane	TOC	Dissolved Metals
01-MW214	Upgradient well for monitoring influent concentrations		✓	✓	✓				✓	✓		✓	✓	✓	✓							✓	✓	✓	✓						✓	✓	✓	✓					
01-MW231	Performance data within the PRB; assessment of injection zone of influence		✓	✓	✓				✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	
01-MW232	Downgradient well to monitor effluent concentrations		✓	✓	✓				✓	✓		✓	✓	✓	✓							✓	✓	✓	✓						✓	✓	✓	✓					
01-MW233	Downgradient well to monitor effluent concentrations		✓	✓	✓				✓	✓		✓	✓	✓	✓				✓			✓	✓	✓	✓						✓	✓	✓	✓					
01-MW234	Downgradient well to monitor effluent concentrations		✓	✓	✓				✓	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓	✓	✓					✓	✓	✓	✓	✓					✓
01-PZ15	Upgradient well for monitoring influent concentrations		✓	✓	✓				✓	✓		✓	✓	✓	✓							✓	✓	✓	✓						✓	✓	✓	✓					

Notes:

[a] To be conducted within 15 to 30 days of the completion of substrate injection.

[b] Anions include nitrate and sulfate.

✓ Indicates that sample will be collected and analyzed for the listed analyte.

Table 6-16: ISB Performance Monitoring Plan – Station Boundary PRB

Proposed Analyses – First Month (Single Event)[a]

Monitoring Locations	Rationale for Well Selection	Perchlorate	VOCs[b]	DO	ORP	pH	Alkalinity	Anions[c]	Methane	Ethene	Ethane	Bromide	TOC	Dissolved Metals
02-NEW16	Upgradient well for monitoring influent concentrations			✓	✓	✓						✓	✓	
02-NEW36	Upgradient well for monitoring influent concentrations			✓	✓	✓						✓	✓	
02-NEW37	Performance data within the PRB; assessment of injection zone of influence			✓	✓	✓						✓	✓	
02-NEW38	Downgradient well to monitor effluent concentrations			✓	✓	✓						✓	✓	
02-NEW39	Downgradient well to monitor effluent concentrations			✓	✓	✓						✓	✓	✓
02-NEW40	Downgradient well to monitor effluent concentrations			✓	✓	✓						✓	✓	

Proposed Analyses – Year 1 (Quarterly)

Monitoring Locations	Perchlorate	VOCs[a]	DO	ORP	pH	Alkalinity	Anions[c]	Methane	Ethene	Ethane	Bromide	TOC	Dissolved Metals
02-NEW16	✓	✓	✓	✓	✓								
02-NEW36	✓	✓	✓	✓	✓								
02-NEW37	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
02-NEW38	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	
02-NEW39	✓	✓	✓	✓	✓								✓
02-NEW40	✓	✓	✓	✓	✓						✓		

Proposed Analyses – Years 2 and 3 (Semi-Annually)

Monitoring Locations	Perchlorate	VOCs[a]	DO	ORP	pH	Alkalinity	Anions[c]	Methane	Ethene	Ethane	TOC	Dissolved Metals
02-NEW16	✓	✓	✓	✓	✓							
02-NEW36	✓	✓	✓	✓	✓							
02-NEW37	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
02-NEW38	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	
02-NEW39	✓	✓	✓	✓	✓							✓
02-NEW40	✓	✓	✓	✓	✓							

Proposed Analyses – After Year 3 (Annually)

Monitoring Locations	Perchlorate	VOCs[a]	DO	ORP	pH	Alkalinity	Anions[c]	Methane	Ethene	Ethane	TOC	Dissolved Metals
02-NEW16	✓	✓	✓	✓	✓							
02-NEW36	✓	✓	✓	✓	✓							
02-NEW37	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
02-NEW38	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	
02-NEW39	✓	✓	✓	✓	✓							✓
02-NEW40	✓	✓	✓	✓	✓							

Notes:

[a] To be conducted within 15 to 30 days of the completion of substrate injection.

[b] Analytes include COCs for IRP Site 2 groundwater (TCE, cis-1,2-DCE, PCE, 1,2-DCA, 1,1,2-TCA) and VC (generated due to reductive dechlorination of TCE and cis-1,2-DCE).

[c] Anions include nitrate and sulfate.

✓ Indicates that sample will be collected and analyzed for the listed analyte.

Table 6-17: Summary of Information Obtained from Proposed Analytes

Analyte	Information Obtained from Analyses
COCs (Perchlorate and VOCs[a])	Extent and rate of biodegradation of perchlorate and/or TCE.
DO, ORP, Anions[b], Methane	Changes in geochemistry of groundwater due to substrate injection to evaluate if optimum conditions are created to stimulate indigenous bacteria to degrade perchlorate and/or VOCs.
pH	Evalute if pH of groundwater is desirable for biological processes to occur.
Alkalinity	Indicator of biodegradation and the buffering capacity of the aquifer (neutralization of acids generated during substrate fermentation).
Ethene[a], Ethane[a]	Evaluate if TCE and cis-1,2-DCE are being completed dechlorinated to ethene and ethane.
Bromide	Indicator of substrate injection zone of influence in conjunction with concentrations of TOC, geochemical parameters, and COCs.
TOC	Indicator of substrate injection zone of influence in conjunction with concentrations of bromide, geochemical parameters, and COCs.
Dissolved Metals	Evaluate potential metals migration due to anaerobic conditions.

Notes

[a] For Station Boundary PRB only.

[b] Anions include nitrate and sulfate.

Table 6-18: Groundwater Monitoring Plan – Overall Perchlorate Extent Monitoring

Area	Monitoring Locations	Proposed Analyses															
		Year 1 (First Event)[a]				Year 1 (Semi-annually)[b]				Year 1 through 3 (Semi-annually)[c]				After Year 3 (Annually)[d]			
		Perchlorate	DO	ORP	pH	Perchlorate	DO	ORP	pH	Perchlorate	DO	ORP	pH	Perchlorate	DO	ORP	pH
Upgradient of Source Area	01-MW101					✓	✓	✓	✓								
	01-MW102	✓	✓	✓	✓												
	01-MW221					✓	✓	✓	✓								
	01-PZ01					✓	✓	✓	✓								
	01-PZ02					✓	✓	✓	✓								
	01-PZ04					✓	✓	✓	✓								
	01-PZ05					✓	✓	✓	✓								
	01-PZ06	✓	✓	✓	✓												
	01-PZ12	✓	✓	✓	✓												
Source Area	01-MW204									✓	✓	✓	✓				
	01-MW208					✓	✓	✓	✓								
	01-MW218					✓	✓	✓	✓								
	01-MW220					✓	✓	✓	✓								
	01-MW222					✓	✓	✓	✓								
	01-PZ21B									✓	✓	✓	✓	✓	✓	✓	✓
Intermediate Area	01-DGMW57					✓	✓	✓	✓								
	01-DGMW58					✓	✓	✓	✓								
	01-MW206					✓	✓	✓	✓								
	01-MW207					✓	✓	✓	✓								
	01-MW211									✓	✓	✓	✓	✓	✓	✓	✓
	01-MW212					✓	✓	✓	✓								
	01-MW213					✓	✓	✓	✓								
	01-MW215									✓	✓	✓	✓	✓	✓	✓	✓
	01-MW216					✓	✓	✓	✓								
	01-MW217					✓	✓	✓	✓								
	01-MW223									✓	✓	✓	✓	✓	✓	✓	✓
	01-MW224					✓	✓	✓	✓								
	01-PZ14					✓	✓	✓	✓								
	01-PZ16					✓	✓	✓	✓								
	02-NEW11					✓	✓	✓	✓								
	18BGMW24					✓	✓	✓	✓								

Table 6-18: Groundwater Monitoring Plan – Overall Perchlorate Extent Monitoring

Area	Monitoring Locations	Proposed Analyses															
		Year 1 (First Event)[a]				Year 1 (Semi-annually)[b]				Year 1 through 3 (Semi-annually)[c]				After Year 3 (Annually)[d]			
		Perchlorate	DO	ORP	pH	Perchlorate	DO	ORP	pH	Perchlorate	DO	ORP	pH	Perchlorate	DO	ORP	pH
IRP Site 2 Area	02_NEW02A					✓	✓	✓	✓								
	02_NEW07A[e]					✓	✓	✓	✓								
	02-NEW08A									✓	✓	✓	✓				
	02-NEW15					✓	✓	✓	✓								
	02-NEW16									✓	✓	✓	✓	✓	✓	✓	✓
	02-NEW19					✓	✓	✓	✓								
	02_NEW26A[e]					✓	✓	✓	✓								
	02_NEW27A[e]					✓	✓	✓	✓								
	02-NEW28A									✓	✓	✓	✓	✓	✓	✓	✓
	02-NEW29					✓	✓	✓	✓								
	02-NEW30									✓	✓	✓	✓				
	02-NEW42[e]					✓	✓	✓	✓								
	02-PZ10					✓	✓	✓	✓								
	02-PZ12									✓	✓	✓	✓	✓	✓	✓	✓

Notes:

[a] Proposed for wells that have been routine monitored at least once a year and for which perchlorate concentrations are reported to be less than its MCL from July 2004 to March 2011.

[b] Proposed for monitoring wells where perchlorate concentration have exceeded its MCL at least once in the past but for which latest available data (as of January 2013) show perchlorate less than its MCL.

[c] Proposed for monitoring wells where latest available data (as of January 2013) show perchlorate concentration exceeding its MCL.

[d] Proposed for monitoring wells where latest available data (as of January 2013) show perchlorate concentration exceeding its MCL. Monitoring Plan after year 3 will be revised appropriately based on the evaluation of results from Years 1 through 3.

[e] The need for continued groundwater sampling and analysis for perchlorate after Year 1 for wells 02NEW07A, 02NEW26A, 02NEW27A, and 02NEW42 will be evaluated following comprehensive review of PRB performance data and perchlorate distribution data near the Station Boundary.

✓ Indicates that sample will be collected and analyzed for the listed analyte.

Table 7-1: Screen Intervals Monitoring Wells – IRP Site 2 MNA

Well ID	Existing or Proposed?	Screened Interval (feet bgs)*
02_NEW02A	Existing	66 – 91
02_NEW07A	Existing	122 – 147
02NEW08A	Existing	84 – 104
02NEW19	Existing	86 – 113
02_NEW26A	Existing	73 – 98
02_NEW27A	Existing	92 – 117
02-NEW28A	Proposed	60 – 80
02NEW29	Existing	47 – 67
02-NEW41	Proposed	60 – 80
02-NEW42	Proposed	70 – 90
02PZ05	Existing	80 – 100

Notes:
* Well screen placements and lengths may be modified during field implementation activities based on field observations including depth of alluvium/bedrock contact and groundwater.

bgs below ground surface
ID identification
MDA monitored natural attenuation

Table 7-2: Sampling and Analysis Schedule - IRP Site 2 MNA

Well ID Proposed for Sampling	Location Relative to TCE Plume/ Purpose	Proposed Analyses											
		Year 1 through 3 (Annually)				Year 1 through 3 (Semi-annually)				After Year 3 (Annually)			
		VOCs[a]	DO	ORP	pH	VOCs[a]	DO	ORP	pH	VOCs[a]	DO	ORP	pH
02_NEW02A	Define extent of TCE exceeding its RG to the southeast	✓	✓	✓	✓					✓	✓	✓	✓
02_NEW07A	Define downgradient extent of TCE plume	✓	✓	✓	✓					✓	✓	✓	✓
02-NEW19	TCE concentrations and extent to the northwest					✓	✓	✓	✓	✓	✓	✓	✓
02_NEW26A	Define extent of TCE exceeding its RG to the southeast					✓	✓	✓	✓	✓	✓	✓	✓
02_NEW27A	Define downgradient extent of TCE plume	✓	✓	✓	✓					✓	✓	✓	✓
02-NEW28A	TCE concentrations near the former Station Boundary					✓	✓	✓	✓	✓	✓	✓	✓
02-NEW29	TCE concentrations in the central portion of the plume					✓	✓	✓	✓	✓	✓	✓	✓
02-NEW41	Define TCE concentrations exceeding its RG upgradient of well 02-NEW29	✓	✓	✓	✓					✓	✓	✓	✓
02-NEW42	Define TCE concentrations and extent to the west/northwest	✓	✓	✓	✓					✓	✓	✓	✓
02-PZ05	Define extent of TCE exceeding its RG to the northwest	✓	✓	✓	✓					✓	✓	✓	✓
02-NEW08A	Verify that PCE concentrations are less than its RG	✓	✓	✓	✓					✓	✓	✓	✓

Notes:

[a] Analytes include COCs for IRP Site 2 groundwater (TCE, cis-1,2-DCE, PCE, 1,2-DCA, 1,1,2-TCA).

Table 7-3: Data Evaluation – IRP Site 2 MNA

Data Evaluation Objective	Proposed Methods	Proposed Frequency
Analysis of changes (if any) to groundwater flow direction and rates	Groundwater equipotential maps	These maps will be generated after each performance monitoring round.
Analysis of temporal trends in COC concentrations	Concentration versus time graphs for all monitoring wells	These graphs will be first generated after collection of 2 years of data (four data points for each COC and for each well) and will be subsequently updated after each performance monitoring round.
	Statistical hypothesis tests for detecting trends such as Mann-Kendall test	Statistical tests will be initiated after collection of 3 years of concentration data.
Analysis of spatial trends in COC concentrations	Mapping of COC concentration data in plan view and/or cross-section	The mapping of COC concentration data will be performed after each performance monitoring round.
Analysis of COC concentrations in downgradient wells to evaluate plume migration	Comparison of COC concentrations in downgradient wells with their respective RGs	This comparison will be performed after each performance monitoring round.
Evaluate if RGs are attained.	Comparison of COC concentrations in all monitoring wells with their respective RGs	This comparison will be performed after each performance monitoring round.

Notes:
COC contaminant of concern
RG remediation goal
MDA monitored natural attenuation

Table 8-1. Potentially Applicable Nationwide Permit General Conditions

Nationwide Permit General Condition Number [a]	Topic	Demonstration of Compliance [b]
2	Aquatic Life Movements.	As Borrego Canyon Wash is not a perennial stream, and no aquatic, endangered species were found within the project area, no particular concerns with aquatic life movement are present. Even so, project will be designed to maintain typical, low flows to sustain the riparian habitat within and adjacent to Borrego Wash.
4	Migratory Bird Breeding Areas.	Coordination with the USFWS (see Section 8.3.3 for details).
6	Suitable Material	Only suitable material will be utilized within and adjacent to Borrego Canyon Wash.
9	Management of Water Flows	The injection/monitoring wells will not change the pre-construction course, condition, capacity, and location of Borrego Canyon Wash.
11	Equipment	Measures such as use of steel plates will be used during equipment operation to minimize soil disturbance. A selected locations temporary gravel backfill may be used for equipment access.
12	Soil Erosion and Sediment Controls	Soil erosion/sediment control will be implemented during construction activities. Best management practices (BMPs) will be implemented)
13	Removal of Temporary Fills	Gravel used at selected locations for access will be removed after project completion
18	Endangered Species	Coordination with the USFWS (see Section 8.3.3 for details) .
19	Migratory Birds and Bald and Golden Eagles	Coordination with the USFWS (see Section 8.3.3 for details) .
20	Historic Properties	No historic properties have been documented.
21	Discovery of Previously Unknown Remains and Artifacts	No remains or artifacts have been documented.
23	Mitigation	All impacts are anticipated to be temporary in nature, and will likely consist of tree/shrub trimming.
25	Water Quality	Soil erosion/sediment control will be implemented during construction activities. BMPs will be implemented.
27	Regional and Case-by-Case Conditions	No Regional Conditions specifically relate to Nationwide Permit (NWP) No. 38. Although the United States Army Corps of Engineers (USACE) revoked most NWPs within the San Diego Creek Watershed (Federal Register 2012), NWP No. 38 was not revoked and may still be utilized.

Notes:
Notes:
[a] Source: Federal Register, Vol. 77, No. 34; Pages 10282 – 10290. Only 14 applicable General Conditions are included in this table (out of a total of 31 General Conditions and an additional 10 Regional Conditions).
[b] Although a Section 404 Permit is not required for CERCLA authorized projects, proposed project work will proceed in compliance with General Conditions of the 2012 NWPs.
BMP best management practices
NPDES National Pollutant Discharge Elimination System
NWP Nationwide Permit
SWPPP Storm Water Pollution Prevention Plan
USACE United States Army Corps of Engineers
USFWS United States Fish and Wildlife Service

Appendix A
Input Parameters and Output Sheets — ESTCP Substrate Estimating Tool

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Source Area PRB

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Table S.1 Input for Substrate Requirements in Hydrogen Equivalents

Site Name: IRP Site 1 Groundwater Source Area PRB

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NOTE: Unshaded boxes are user input.

1. Treatment Zone Physical Dimensions	Values	Range	Units	User Notes
Width (Perpendicular to predominant groundwater flow direction)	40	1-10,000	feet	Based on the injection well design presented in the Work Plan
Length (Parallel to predominant groundwater flow)	15	1-1,000	feet	Based on the injection well design presented in the Work Plan
Saturated Thickness	15	1-100	feet	Based on the injection well design presented in the Work Plan
Treatment Zone Cross Sectional Area	600	--	ft^2	
Treatment Zone Volume	9,000	--	ft^3	
Treatment Zone Total Pore Volume (total volume x total porosity)	22,895	--	gallons	
Treatment Zone Effective Pore Volume (total volume x effective porosity)	18,181	--	gallons	
Design Period of Performance	3.0	.5 to 5	year	
Design Factor (times the electron acceptor hydrogen demand)	3.0	2 to 20	unitless	
2. Treatment Zone Hydrogeologic Properties				
Total Porosity	34%	.05-50	percent	Literature-based value for Sandstone.
Effective Porosity	27%	.05-50	percent	Literature-based value for Sandstone.
Average Aquifer Hydraulic Conductivity	0.85	.01-1000	ft/day	Based on the pump tests conducted at Site 1
Average Hydraulic Gradient	0.05	0.0001-0.1	ft/ft	Based on groundwater level data for Site 1
Average Groundwater Seepage Velocity through the Treatment Zone	0.16	--	ft/day	
Average Groundwater Seepage Velocity through the Treatment Zone	57.5	--	ft/yr	
Average Groundwater Discharge through the Treatment Zone	69,639	--	gallons/year	
Soil Bulk Density	1.45	1.4-2.0	gm/cm^3	
Soil Fraction Organic Carbon (foc)	0.05%	0.01-10	percent	
3. Native Electron Acceptors				
A. Aqueous-Phase Native Electron Acceptors				
Oxygen	3.4	0.01 to 10	mg/L	Average value for Site 1 area (see table in the Work Plan)
Nitrate	14.00	0.1 to- 20	mg/L	Average value for Site 1 area (see table in the Work Plan)
Sulfate	55	10 to 5,000	mg/L	Average value for Site 1 area (see table in the Work Plan)
Carbon Dioxide (estimated as the amount of Methane produced)	10.0	0.1 to 20	mg/L	Average value for Site 1 area (see table in the Work Plan)
B. Solid-Phase Native Electron Acceptors				
Manganese (IV) (estimated as the amount of Mn (II) produced)	20	0.1 to 20	mg/L	
Iron (III) (estimated as the amount of Fe (II) produced)	20	0.1 to 20	mg/L	
4. Contaminant Electron Acceptors				
Tetrachloroethene (PCE)	0.000	--	mg/L	
Trichloroethene (TCE)	0.000	--	mg/L	
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	0.000	--	mg/L	
Vinyl Chloride (VC)	0.000	--	mg/L	
Carbon Tetrachloride (CT)	0.000	--	mg/L	
Trichloromethane (or chloroform) (CF)	0.000	--	mg/L	
Dichloromethane (or methylene chloride) (MC)	0.000	--	mg/L	
Chloromethane	0.000	--	mg/L	
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	0.000	--	mg/L	
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	0.000	--	mg/L	
Dichloroethane (1,1-DCA and 1,2-DCA)	0.000	--	mg/L	
Chloroethane	0.000	--	mg/L	
Perchlorate	0.119	--	mg/L	March 2011 perchlorate concentration at 01-PZ21A
5. Aquifer Geochemistry (Optional Screening Parameters)				
A. Aqueous Geochemistry				
Oxidation-Reduction Potential (ORP)	103	-400 to +500	mV	Average
Temperature		5.0 to 30	ºC	
pH	7.3	4.0 to 10.0	su	
Alkalinity	173	10 to 1,000	mg/L	
Total Dissolved Solids (TDS, or salinity)		10 to 1,000	mg/L	
Specific Conductivity		100 to 10,000	µs/cm	
Chloride		10 to 10,000	mg/L	
Sulfide - Pre injection	0.0	0.1 to 100	mg/L	
Sulfide - Post injection	0.0	0.1 to 100	mg/L	
B. Aquifer Matrix				
Total Iron		200 to 20,000	mg/kg	
Cation Exchange Capacity	NA	1.0 to 10	meq/100 g	
Neutralization Potential		1.0 to 100	Percent as $CaCO_3$	

NOTES:

Table S.5 Output for Substrate Requirements in Hydrogen Equivalents

Site Name: IRP Site 1 Groundwater Source Area PRB

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1. Treatment Zone Physical Dimensions

	Values	Units	Values	Units
Width (perpendicular to groundwater flow)	40	feet	12	meters
Length (parallel to groundwater flow)	15	feet	4.6	meters
Saturated Thickness	15	feet	4.6	meters
Design Period of Performance	3	years	3	years

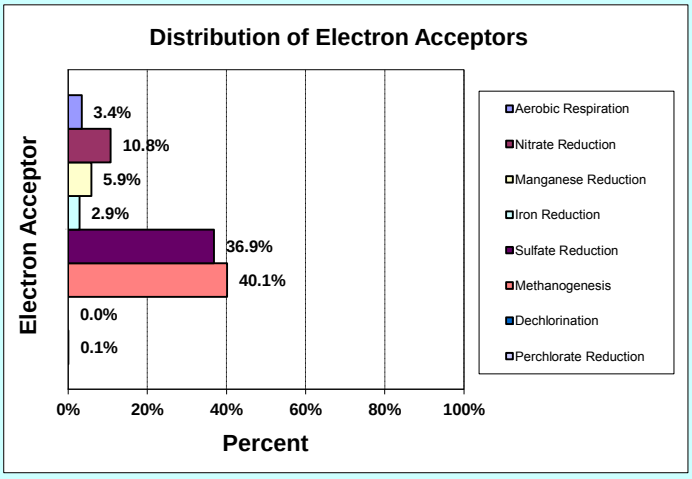
2. Treatment Zone Hydrogeologic Properties

	Values	Units	Values	Units
Total Porosity	0.34	percent	0.34	percent
Effective Porosity	0.27	percent	0.27	percent
Average Aquifer Hydraulic Conductivity	0.85	ft/day	3.0E-04	cm/sec
Average Hydraulic Gradient	0.05	ft/ft	0.05	m/m
Average Groundwater Seepage Velocity	0.16	ft/day	4.8E+00	cm/day
Average Groundwater Seepage Velocity	57	ft/yr	17.5	m/yr
Effective Treatment Zone Pore Volume	18,181	gallons	68,822	liters
Groundwater Flux (per year)	69,639	gallons/year	263,604	liters/year
Total Groundwater Volume Treated (over entire design period)	227,097	gallons total	859,633	liters total

3. Distribution of Electron Acceptor Demand

	Percent of Total	Hydrogen Demand (lb)
Aerobic Respiration	3.4%	0.811
Nitrate Reduction	10.8%	2.554
Sulfate Reduction	36.9%	8.751
Manganese Reduction	5.9%	1.391
Iron Reduction	2.9%	0.684
Methanogenesis	40.1%	9.523
Dechlorination	0.0%	0.000
Perchlorate Reduction	0.1%	0.018
Totals:	**100.00%**	**23.73**

Hydrogen demand in pounds/gallon:	1.05E-04
Hydrogen demand in grams per liter:	1.25E-02



4. Substrate Equivalents: Design Factor = 3.0

Product	Quantity (lb)	Quantity (gallons)	Effective Concentration (mg/L)	Effective concentration is for total volume of groundwater treated.
1. Sodium Lactate Product	3,300	300	839	as lactic acid
2. Molasses Product	2,518	210	797	as sucrose
3. Fructose Product	1,989	178	840	as fructose
4. Ethanol Product	1,017	147	429	as ethanol
5. Sweet Dry Whey (lactose)	1,569	sold by pound	579	as lactose
6. HRC®	1,206	sold by pound	509	as 40% lactic acid/40% glycerol
7. Linoleic Acid (Soybean Oil)	619	79	327	as soybean oil
8. Emulsified Vegetable Oil	1,032	132	327	as soybean oil

Notes:
1. Quantity assumes product is 60% sodium lactate by weight.
2. Quantity assumes product is 60% sucrose by weight and weighs 12 pounds per gallon.
3. Quantity assumes product is 80% fructose by weight and weighs 11.2 pounds per gallon.
4. Quantity assumes product is 80% ethanol by weight and weighs 6.9 pounds per gallon.
5. Quantity assumes product is 70% lactose by weight.
6. Quantity assumes HRC® is 40% lactic acid and 40% glycerol by weight.
7. Quantity of neat soybean oil, corn oil, or canola oil.
8. Quantity assumes commercial product is 60% soybean oil by weight.

Source Area Treatment – Zone 1

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Table S.1 Input for Substrate Requirements in Hydrogen Equivalents

Site Name: Site 1 Groundwater Source Area Direct Injection

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NOTE: Unshaded boxes are user input.

1. Treatment Zone Physical Dimensions	Values	Range	Units	User Notes
Width (Perpendicular to predominant groundwater flow direction)	338	1-10,000	feet	Based on the injection well design presented in the Work Plan
Length (Parallel to predominant groundwater flow)	250	1-1,000	feet	Based on the injection well design presented in the Work Plan
Saturated Thickness	25	1-100	feet	Based on the injection well design presented in the Work Plan
Treatment Zone Cross Sectional Area	8450	--	ft^2	
Treatment Zone Volume	2,112,500	--	ft^3	
Treatment Zone Total Pore Volume (total volume x total porosity)	5,373,947	--	gallons	
Treatment Zone Effective Pore Volume (total volume x effective porosity)	4,267,546	--	gallons	
Design Period of Performance	0.5	.5 to 5	year	
Design Factor (times the electron acceptor hydrogen demand)	2.0	2 to 20	unitless	
2. Treatment Zone Hydrogeologic Properties				
Total Porosity	34%	.05-50	percent	Literature-based value for Sandstone.
Effective Porosity	27%	.05-50	percent	Literature-based value for Sandstone.
Average Aquifer Hydraulic Conductivity	0.85	.01-1000	ft/day	Based on the pump tests conducted at Site 1
Average Hydraulic Gradient	0.05	0.0001-0.1	ft/ft	Based on groundwater level data for Site 1
Average Groundwater Seepage Velocity through the Treatment Zone	0.16	--	ft/day	
Average Groundwater Seepage Velocity through the Treatment Zone	57.5	--	ft/yr	
Average Groundwater Discharge through the Treatment Zone	980,745	--	gallons/year	
Soil Bulk Density	1.45	1.4-2.0	gm/cm^3	
Soil Fraction Organic Carbon (foc)	0.05%	0.01-10	percent	
3. Native Electron Acceptors				
A. Aqueous-Phase Native Electron Acceptors				
Oxygen	3.4	0.01 to 10	mg/L	Average value for Site 1 area (see table in the Work Plan)
Nitrate	14.00	0.1 to- 20	mg/L	Average value for Site 1 area (see table in the Work Plan)
Sulfate	55	10 to 5,000	mg/L	Average value for Site 1 area (see table in the Work Plan)
Carbon Dioxide (estimated as the amount of Methane produced)	10.0	0.1 to 20	mg/L	Average value for Site 1 area (see table in the Work Plan)
B. Solid-Phase Native Electron Acceptors				
Manganese (IV) (estimated as the amount of Mn (II) produced)	20	0.1 to 20	mg/L	
Iron (III) (estimated as the amount of Fe (II) produced)	20	0.1 to 20	mg/L	
4. Contaminant Electron Acceptors				
Tetrachloroethene (PCE)	0.000	--	mg/L	
Trichloroethene (TCE)	0.000	--	mg/L	
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	0.000	--	mg/L	
Vinyl Chloride (VC)	0.000	--	mg/L	
Carbon Tetrachloride (CT)	0.000	--	mg/L	
Trichloromethane (or chloroform) (CF)	0.000	--	mg/L	
Dichloromethane (or methylene chloride) (MC)	0.000	--	mg/L	
Chloromethane	0.000	--	mg/L	
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	0.000	--	mg/L	
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	0.000	--	mg/L	
Dichloroethane (1,1-DCA and 1,2-DCA)	0.000	--	mg/L	
Chloroethane	0.000	--	mg/L	
Perchlorate	0.213	--	mg/L	Average March 2011 perchlorate conc. in Source Area
5. Aquifer Geochemistry (Optional Screening Parameters)				
A. Aqueous Geochemistry				
Oxidation-Reduction Potential (ORP)	103	-400 to +500	mV	Average
Temperature		5.0 to 30	ºC	
pH	7.3	4.0 to 10.0	su	
Alkalinity	173	10 to 1,000	mg/L	
Total Dissolved Solids (TDS, or salinity)		10 to 1,000	mg/L	
Specific Conductivity		100 to 10,000	µs/cm	
Chloride		10 to 10,000	mg/L	
Sulfide - Pre injection	0.0	0.1 to 100	mg/L	
Sulfide - Post injection	0.0	0.1 to 100	mg/L	
B. Aquifer Matrix				
Total Iron		200 to 20,000	mg/kg	
Cation Exchange Capacity	NA	1.0 to 10	meq/100 g	
Neutralization Potential		1.0 to 100	Percent as $CaCO_3$	

NOTES:

Table S.5 Output for Substrate Requirements in Hydrogen Equivalents

Site Name: Site 1 Groundwater Source Area Direct Injection

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1. Treatment Zone Physical Dimensions

	Values	Units	Values	Units
Width (perpendicular to groundwater flow)	338	feet	103	meters
Length (parallel to groundwater flow)	250	feet	76.2	meters
Saturated Thickness	25	feet	7.6	meters
Design Period of Performance	0.5	years	0.5	years

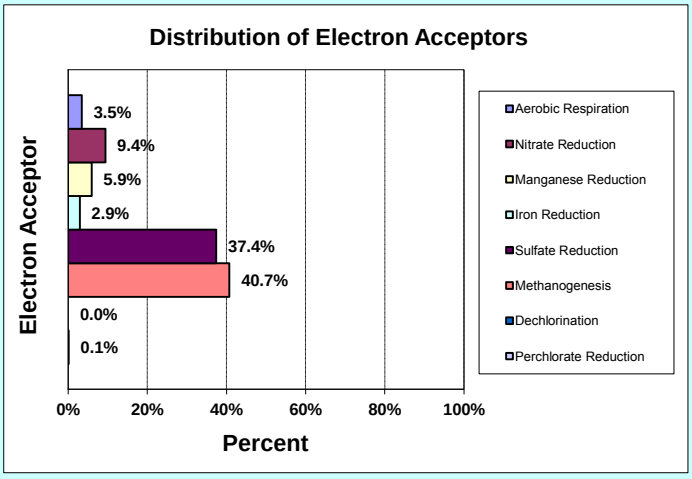
2. Treatment Zone Hydrogeologic Properties

	Values	Units	Values	Units
Total Porosity	0.34	percent	0.34	percent
Effective Porosity	0.27	percent	0.27	percent
Average Aquifer Hydraulic Conductivity	0.85	ft/day	3.0E-04	cm/sec
Average Hydraulic Gradient	0.05	ft/ft	0.05	m/m
Average Groundwater Seepage Velocity	0.16	ft/day	4.8E+00	cm/day
Average Groundwater Seepage Velocity	57	ft/yr	17.5	m/yr
Effective Treatment Zone Pore Volume	4,267,546	gallons	16,153,967	liters
Groundwater Flux (per year)	980,745	gallons/year	3,712,421	liters/year
Total Groundwater Volume Treated (over entire design period)	4,757,918	gallons total	18,010,177	liters total

3. Distribution of Electron Acceptor Demand

	Percent of Total	Hydrogen Demand (lb)
Aerobic Respiration	3.5%	17.001
Nitrate Reduction	9.4%	46.121
Sulfate Reduction	37.4%	183.346
Manganese Reduction	5.9%	29.140
Iron Reduction	2.9%	14.330
Methanogenesis	40.7%	199.511
Dechlorination	0.0%	0.000
Perchlorate Reduction	0.1%	0.686
Totals:	**100.00%**	**490.13**

Hydrogen demand in pounds/gallon:	1.03E-04
Hydrogen demand in grams per liter:	1.23E-02



4. Substrate Equivalents: Design Factor = 2.0

Product	Quantity (lb)	Quantity (gallons)	Effective Concentration (mg/L)	Effective concentration is for total volume of groundwater treated.
1. Sodium Lactate Product	45,437	4,131	552	as lactic acid
2. Molasses Product	34,675	2,890	524	as sucrose
3. Fructose Product	27,382	2,445	552	as fructose
4. Ethanol Product	14,001	2,029	282	as ethanol
5. Sweet Dry Whey (lactose)	21,597	sold by pound	381	as lactose
6. HRC®	16,602	sold by pound	335	as 40% lactic acid/40% glycerol
7. Linoleic Acid (Soybean Oil)	8,524	1,093	215	as soybean oil
8. Emulsified Vegetable Oil	14,207	1,821	215	as soybean oil

Notes:
1. Quantity assumes product is 60% sodium lactate by weight.
2. Quantity assumes product is 60% sucrose by weight and weighs 12 pounds per gallon.
3. Quantity assumes product is 80% fructose by weight and weighs 11.2 pounds per gallon.
4. Quantity assumes product is 80% ethanol by weight and weighs 6.9 pounds per gallon.
5. Quantity assumes product is 70% lactose by weight.
6. Quantity assumes HRC® is 40% lactic acid and 40% glycerol by weight.
7. Quantity of neat soybean oil, corn oil, or canola oil.
8. Quantity assumes commercial product is 60% soybean oil by weight.

Source Area Treatment – Zone 2 and Upgradient of Zone 1

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Table S.1 Input for Substrate Requirements in Hydrogen Equivalents

Site Name: Site 1 Groundwater Source Area Spot Treatment

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NOTE: Unshaded boxes are user input.

1. Treatment Zone Physical Dimensions	Values	Range	Units	User Notes
Width (Perpendicular to predominant groundwater flow direction)	20	1-10,000	feet	Based on the injection well design presented in the Work Plan
Length (Parallel to predominant groundwater flow)	20	1-1,000	feet	Based on the injection well design presented in the Work Plan
Saturated Thickness	25	1-100	feet	Based on the injection well design presented in the Work Plan
Treatment Zone Cross Sectional Area	500	--	ft^2	
Treatment Zone Volume	10,000	--	ft^3	
Treatment Zone Total Pore Volume (total volume x total porosity)	25,439	--	gallons	
Treatment Zone Effective Pore Volume (total volume x effective porosity)	20,201	--	gallons	
Design Period of Performance	0.5	.5 to 5	year	
Design Factor (times the electron acceptor hydrogen demand)	2.0	2 to 20	unitless	
2. Treatment Zone Hydrogeologic Properties				
Total Porosity	34%	.05-50	percent	Literature-based value for Sandstone.
Effective Porosity	27%	.05-50	percent	Literature-based value for Sandstone.
Average Aquifer Hydraulic Conductivity	0.028	.01-1000	ft/day	Based on the pump tests conducted at Site 1
Average Hydraulic Gradient	0.06	0.0001-0.1	ft/ft	Based on groundwater level data for Site 1
Average Groundwater Seepage Velocity through the Treatment Zone	0.01	--	ft/day	
Average Groundwater Seepage Velocity through the Treatment Zone	2.3	--	ft/yr	
Average Groundwater Discharge through the Treatment Zone	2,294	--	gallons/year	
Soil Bulk Density	1.45	1.4-2.0	gm/cm^3	
Soil Fraction Organic Carbon (foc)	0.05%	0.01-10	percent	
3. Native Electron Acceptors				
A. Aqueous-Phase Native Electron Acceptors				
Oxygen	3.4	0.01 to 10	mg/L	Average value for Site 1 area (see table in the Work Plan)
Nitrate	14.00	0.1 to- 20	mg/L	Average value for Site 1 area (see table in the Work Plan)
Sulfate	55	10 to 5,000	mg/L	Average value for Site 1 area (see table in the Work Plan)
Carbon Dioxide (estimated as the amount of Methane produced)	10.0	0.1 to 20	mg/L	Average value for Site 1 area (see table in the Work Plan)
B. Solid-Phase Native Electron Acceptors				
Manganese (IV) (estimated as the amount of Mn (II) produced)	20	0.1 to 20	mg/L	
Iron (III) (estimated as the amount of Fe (II) produced)	20	0.1 to 20	mg/L	
4. Contaminant Electron Acceptors				
Tetrachloroethene (PCE)	0.000	--	mg/L	
Trichloroethene (TCE)	0.000	--	mg/L	
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	0.000	--	mg/L	
Vinyl Chloride (VC)	0.000	--	mg/L	
Carbon Tetrachloride (CT)	0.000	--	mg/L	
Trichloromethane (or chloroform) (CF)	0.000	--	mg/L	
Dichloromethane (or methylene chloride) (MC)	0.000	--	mg/L	
Chloromethane	0.000	--	mg/L	
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	0.000	--	mg/L	
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	0.000	--	mg/L	
Dichloroethane (1,1-DCA and 1,2-DCA)	0.000	--	mg/L	
Chloroethane	0.000	--	mg/L	
Perchlorate	0.213	--	mg/L	Average March 2011 perchlorate conc. in Source Area
5. Aquifer Geochemistry (Optional Screening Parameters)				
A. Aqueous Geochemistry				
Oxidation-Reduction Potential (ORP)	103	-400 to +500	mV	Average
Temperature		5.0 to 30	ºC	
pH	7.3	4.0 to 10.0	su	
Alkalinity	173	10 to 1,000	mg/L	
Total Dissolved Solids (TDS, or salinity)		10 to 1,000	mg/L	
Specific Conductivity		100 to 10,000	µs/cm	
Chloride		10 to 10,000	mg/L	
Sulfide - Pre injection	0.0	0.1 to 100	mg/L	
Sulfide - Post injection	0.0	0.1 to 100	mg/L	
B. Aquifer Matrix				
Total Iron		200 to 20,000	mg/kg	
Cation Exchange Capacity	NA	1.0 to 10	meq/100 g	
Neutralization Potential		1.0 to 100	Percent as $CaCO_3$	

NOTES:

Table S.5 Output for Substrate Requirements in Hydrogen Equivalents

Site Name: Site 1 Groundwater Source Area Spot Treatment

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1. Treatment Zone Physical Dimensions

	Values	Units	Values	Units
Width (perpendicular to groundwater flow)	20	feet	6	meters
Length (parallel to groundwater flow)	20	feet	6.1	meters
Saturated Thickness	25	feet	7.6	meters
Design Period of Performance	0.5	years	0.5	years

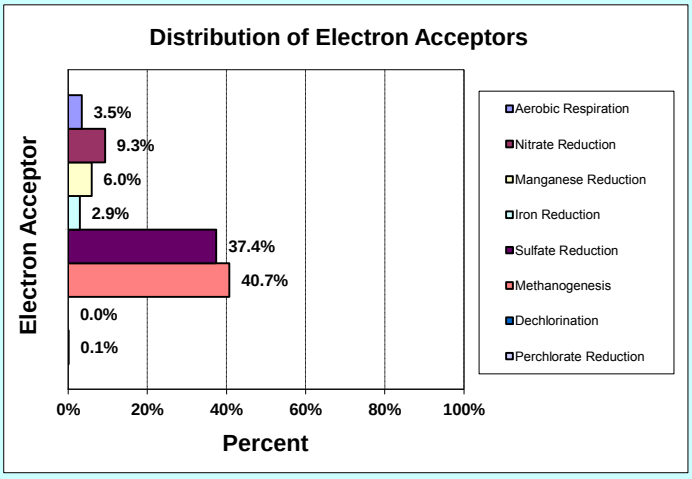
2. Treatment Zone Hydrogeologic Properties

	Values	Units	Values	Units
Total Porosity	0.34	percent	0.34	percent
Effective Porosity	0.27	percent	0.27	percent
Average Aquifer Hydraulic Conductivity	0.028	ft/day	9.9E-06	cm/sec
Average Hydraulic Gradient	0.06	ft/ft	0.06	m/m
Average Groundwater Seepage Velocity	0.01	ft/day	1.9E-01	cm/day
Average Groundwater Seepage Velocity	2	ft/yr	0.7	m/yr
Effective Treatment Zone Pore Volume	20,201	gallons	76,468	liters
Groundwater Flux (per year)	2,294	gallons/year	8,683	liters/year
Total Groundwater Volume Treated (over entire design period)	21,348	gallons total	80,810	liters total

3. Distribution of Electron Acceptor Demand

	Percent of Total	Hydrogen Demand (lb)
Aerobic Respiration	3.5%	0.076
Nitrate Reduction	9.3%	0.205
Sulfate Reduction	37.4%	0.823
Manganese Reduction	6.0%	0.131
Iron Reduction	2.9%	0.064
Methanogenesis	40.7%	0.895
Dechlorination	0.0%	0.000
Perchlorate Reduction	0.1%	0.003
Totals:	**100.00%**	**2.20**

Hydrogen demand in pounds/gallon:	1.03E-04
Hydrogen demand in grams per liter:	1.23E-02



4. Substrate Equivalents: Design Factor = 2.0

Product	Quantity (lb)	Quantity (gallons)	Effective Concentration (mg/L)	Effective concentration is for total volume of groundwater treated.
1. Sodium Lactate Product	204	19	551	as lactic acid
2. Molasses Product	155	13	524	as sucrose
3. Fructose Product	123	11	551	as fructose
4. Ethanol Product	63	9	282	as ethanol
5. Sweet Dry Whey (lactose)	97	sold by pound	380	as lactose
6. HRC®	74	sold by pound	334	as 40% lactic acid/40% glycerol
7. Linoleic Acid (Soybean Oil)	38	5	215	as soybean oil
8. Emulsified Vegetable Oil	64	8	215	as soybean oil

Notes:
1. Quantity assumes product is 60% sodium lactate by weight.
2. Quantity assumes product is 60% sucrose by weight and weighs 12 pounds per gallon.
3. Quantity assumes product is 80% fructose by weight and weighs 11.2 pounds per gallon.
4. Quantity assumes product is 80% ethanol by weight and weighs 6.9 pounds per gallon.
5. Quantity assumes product is 70% lactose by weight.
6. Quantity assumes HRC® is 40% lactic acid and 40% glycerol by weight.
7. Quantity of neat soybean oil, corn oil, or canola oil.
8. Quantity assumes commercial product is 60% soybean oil by weight.

Intermediate Area PRB

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Table S.1 Input for Substrate Requirements in Hydrogen Equivalents

Site Name: Intermediate Area PRB

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NOTE: Unshaded boxes are user input.

1. Treatment Zone Physical Dimensions	Values	Range	Units	User Notes
Width (Perpendicular to predominant groundwater flow direction)	150	1-10,000	feet	Based on the injection well design presented in the Work Plan
Length (Parallel to predominant groundwater flow)	15	1-1,000	feet	Based on the injection well design presented in the Work Plan
Saturated Thickness	20	1-100	feet	Based on the injection well design presented in the Work Plan
Treatment Zone Cross Sectional Area	3000	--	ft^2	
Treatment Zone Volume	45,000	--	ft^3	
Treatment Zone Total Pore Volume (total volume x total porosity)	141,410	--	gallons	
Treatment Zone Effective Pore Volume (total volume x effective porosity)	84,173	--	gallons	
Design Period of Performance	3.0	.5 to 5	year	
Design Factor (times the electron acceptor hydrogen demand)	3.0	2 to 20	unitless	
2. Treatment Zone Hydrogeologic Properties				
Total Porosity	42%	.05-50	percent	Literature-based value for fine sand
Effective Porosity	25%	.05-50	percent	Literature-based value for fine sand
Average Aquifer Hydraulic Conductivity	2.84	.01-1000	ft/day	Literature-based value for fine sand
Average Hydraulic Gradient	0.012	0.0001-0.1	ft/ft	Based on groundwater level data
Average Groundwater Seepage Velocity through the Treatment Zone	0.14	--	ft/day	
Average Groundwater Seepage Velocity through the Treatment Zone	49.8	--	ft/yr	
Average Groundwater Discharge through the Treatment Zone	279,210	--	gallons/year	
Soil Bulk Density	1.4	1.4-2.0	gm/cm^3	
Soil Fraction Organic Carbon (foc)	0.05%	0.01-10	percent	
3. Native Electron Acceptors				
A. Aqueous-Phase Native Electron Acceptors				
Oxygen	2.1	0.01 to 10	mg/L	Average value for Intermed area (see table in the Work Plan)
Nitrate	6.20	0.1 to- 20	mg/L	Average value for Intermed area (see table in the Work Plan)
Sulfate	135	10 to 5,000	mg/L	Average value for Intermed area (see table in the Work Plan)
Carbon Dioxide (estimated as the amount of Methane produced)	10.0	0.1 to 20	mg/L	Average value for Intermed area (see table in the Work Plan)
B. Solid-Phase Native Electron Acceptors				
Manganese (IV) (estimated as the amount of Mn (II) produced)	20	0.1 to 20	mg/L	
Iron (III) (estimated as the amount of Fe (II) produced)	20	0.1 to 20	mg/L	
4. Contaminant Electron Acceptors				
Tetrachloroethene (PCE)	0.000	--	mg/L	
Trichloroethene (TCE)	0.000	--	mg/L	
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	0.000	--	mg/L	
Vinyl Chloride (VC)	0.000	--	mg/L	
Carbon Tetrachloride (CT)	0.000	--	mg/L	
Trichloromethane (or chloroform) (CF)	0.000	--	mg/L	
Dichloromethane (or methylene chloride) (MC)	0.000	--	mg/L	
Chloromethane	0.000	--	mg/L	
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	0.000	--	mg/L	
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	0.000	--	mg/L	
Dichloroethane (1,1-DCA and 1,2-DCA)	0.000	--	mg/L	
Chloroethane	0.000	--	mg/L	
Perchlorate	0.124	--	mg/L	Perchlorate concentration in well 01-MW214
5. Aquifer Geochemistry (Optional Screening Parameters)				
A. Aqueous Geochemistry				
Oxidation-Reduction Potential (ORP)	88	-400 to +500	mV	Average
Temperature		5.0 to 30	ºC	
pH	7.2	4.0 to 10.0	su	Average
Alkalinity	269	10 to 1,000	mg/L	Average
Total Dissolved Solids (TDS, or salinity)		10 to 1,000	mg/L	
Specific Conductivity		100 to 10,000	µs/cm	
Chloride		10 to 10,000	mg/L	
Sulfide - Pre injection	0.0	0.1 to 100	mg/L	
Sulfide - Post injection	0.0	0.1 to 100	mg/L	
B. Aquifer Matrix				
Total Iron		200 to 20,000	mg/kg	
Cation Exchange Capacity	NA	1.0 to 10	meq/100 g	
Neutralization Potential		1.0 to 100	Percent as $CaCO_3$	

NOTES:

Table S.5 Output for Substrate Requirements in Hydrogen Equivalents

Site Name: Intermediate Area PRB

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1. Treatment Zone Physical Dimensions

	Values	Units	Values	Units
Width (perpendicular to groundwater flow)	150	feet	46	meters
Length (parallel to groundwater flow)	15	feet	4.6	meters
Saturated Thickness	20	feet	6.1	meters
Design Period of Performance	3	years	3	years

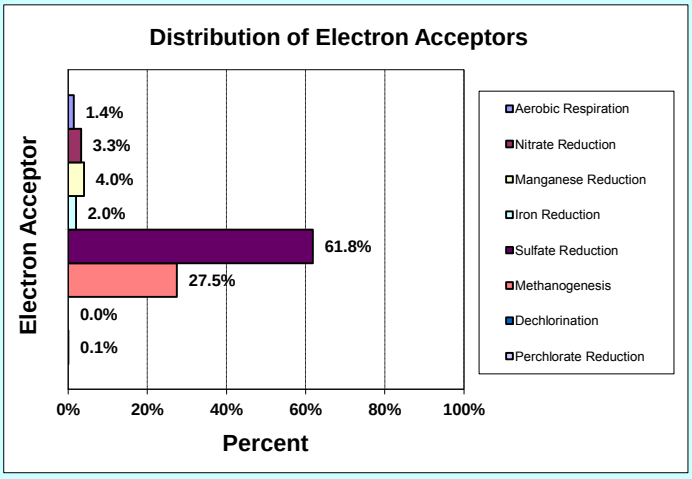
2. Treatment Zone Hydrogeologic Properties

	Values	Units	Values	Units
Total Porosity	0.42	percent	0.42	percent
Effective Porosity	0.25	percent	0.25	percent
Average Aquifer Hydraulic Conductivity	2.84	ft/day	1.0E-03	cm/sec
Average Hydraulic Gradient	0.012	ft/ft	0.012	m/m
Average Groundwater Seepage Velocity	0.14	ft/day	4.2E+00	cm/day
Average Groundwater Seepage Velocity	50	ft/yr	15.2	m/yr
Effective Treatment Zone Pore Volume	84,173	gallons	318,619	liters
Groundwater Flux (per year)	279,210	gallons/year	1,056,896	liters/year
Total Groundwater Volume Treated (over entire design period)	921,803	gallons total	3,489,308	liters total

3. Distribution of Electron Acceptor Demand

	Percent of Total	Hydrogen Demand (lb)
Aerobic Respiration	1.4%	2.034
Nitrate Reduction	3.3%	4.582
Sulfate Reduction	61.8%	86.995
Manganese Reduction	4.0%	5.646
Iron Reduction	2.0%	2.776
Methanogenesis	27.5%	38.653
Dechlorination	0.0%	0.000
Perchlorate Reduction	0.1%	0.077
Totals:	**100.00%**	**140.76**

Hydrogen demand in pounds/gallon:	1.53E-04
Hydrogen demand in grams per liter:	1.83E-02



4. Substrate Equivalents: Design Factor = 3.0

Product	Quantity (lb)	Quantity (gallons)	Effective Concentration (mg/L)	Effective concentration is for total volume of groundwater treated.
1. Sodium Lactate Product	19,574	1,779	1,226	as lactic acid
2. Molasses Product	14,938	1,245	1,165	as sucrose
3. Fructose Product	11,796	1,053	1,227	as fructose
4. Ethanol Product	6,031	874	627	as ethanol
5. Sweet Dry Whey (lactose)	9,304	sold by pound	847	as lactose
6. HRC®	7,152	sold by pound	744	as 40% lactic acid/40% glycerol
7. Linoleic Acid (Soybean Oil)	3,672	471	477	as soybean oil
8. Emulsified Vegetable Oil	6,120	785	477	as soybean oil

Notes:
1. Quantity assumes product is 60% sodium lactate by weight.
2. Quantity assumes product is 60% sucrose by weight and weighs 12 pounds per gallon.
3. Quantity assumes product is 80% fructose by weight and weighs 11.2 pounds per gallon.
4. Quantity assumes product is 80% ethanol by weight and weighs 6.9 pounds per gallon.
5. Quantity assumes product is 70% lactose by weight.
6. Quantity assumes HRC® is 40% lactic acid and 40% glycerol by weight.
7. Quantity of neat soybean oil, corn oil, or canola oil.
8. Quantity assumes commercial product is 60% soybean oil by weight.

Former Station Boundary PRB

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Table S.1 Input for Substrate Requirements in Hydrogen Equivalents

Site Name: IRP Site 1 Groundwater Boundary PRB

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NOTE: Unshaded boxes are user input.

1. Treatment Zone Physical Dimensions	Values	Range	Units	User Notes
Width (Perpendicular to predominant groundwater flow direction)	200	1-10,000	feet	Based on the injection well design presented in the Work Plan
Length (Parallel to predominant groundwater flow)	20	1-1,000	feet	Based on the injection well design presented in the Work Plan
Saturated Thickness	40	1-100	feet	Based on the injection well design presented in the Work Plan
Treatment Zone Cross Sectional Area	8000	--	ft^2	
Treatment Zone Volume	160,000	--	ft^3	
Treatment Zone Total Pore Volume (total volume x total porosity)	418,992	--	gallons	
Treatment Zone Effective Pore Volume (total volume x effective porosity)	143,654	--	gallons	
Design Period of Performance	3.0	.5 to 5	year	
Design Factor (times the electron acceptor hydrogen demand)	3.0	2 to 20	unitless	
2. Treatment Zone Hydrogeologic Properties				
Total Porosity	35%	.05-50	percent	Literature-based value for siltstone
Effective Porosity	12%	.05-50	percent	Literature-based value for siltstone
Average Aquifer Hydraulic Conductivity	0.24	.01-1000	ft/day	Site-specific value based on aquifer tests
Average Hydraulic Gradient	0.05	0.0001-0.1	ft/ft	Based on groundwater level data
Average Groundwater Seepage Velocity through the Treatment Zone	0.10	--	ft/day	
Average Groundwater Seepage Velocity through the Treatment Zone	36.5	--	ft/yr	
Average Groundwater Discharge through the Treatment Zone	262,169	--	gallons/year	
Soil Bulk Density	1.4	1.4-2.0	gm/cm^3	
Soil Fraction Organic Carbon (foc)	0.05%	0.01-10	percent	
3. Native Electron Acceptors				
A. Aqueous-Phase Native Electron Acceptors				
Oxygen	1.8	0.01 to 10	mg/L	Average value for Site 2 area (see table in the Work Plan)
Nitrate	8.60	0.1 to- 20	mg/L	Average value for Site 2 area (see table in the Work Plan)
Sulfate	217	10 to 5,000	mg/L	Average value for Site 2 area (see table in the Work Plan)
Carbon Dioxide (estimated as the amount of Methane produced)	10.0	0.1 to 20	mg/L	Average value for Site 2 area (see table in the Work Plan)
B. Solid-Phase Native Electron Acceptors				
Manganese (IV) (estimated as the amount of Mn (II) produced)	20	0.1 to 20	mg/L	
Iron (III) (estimated as the amount of Fe (II) produced)	20	0.1 to 20	mg/L	
4. Contaminant Electron Acceptors				
Tetrachloroethene (PCE)	0.005	--	mg/L	September 2009 data prior to pilot study.
Trichloroethene (TCE)	0.047	--	mg/L	September 2009 data prior to pilot study.
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	0.000	--	mg/L	
Vinyl Chloride (VC)	0.000	--	mg/L	
Carbon Tetrachloride (CT)	0.000	--	mg/L	
Trichloromethane (or chloroform) (CF)	0.000	--	mg/L	
Dichloromethane (or methylene chloride) (MC)	0.000	--	mg/L	
Chloromethane	0.000	--	mg/L	
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	0.000	--	mg/L	
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	0.000	--	mg/L	
Dichloroethane (1,1-DCA and 1,2-DCA)	0.000	--	mg/L	
Chloroethane	0.000	--	mg/L	
Perchlorate	0.012	--	mg/L	March 2011 perchlorate concentration at 01-PZ21A
5. Aquifer Geochemistry (Optional Screening Parameters)				
A. Aqueous Geochemistry				
Oxidation-Reduction Potential (ORP)	68	-400 to +500	mV	Average
Temperature		5.0 to 30	ºC	
pH	7.0	4.0 to 10.0	su	Average
Alkalinity	337	10 to 1,000	mg/L	Average
Total Dissolved Solids (TDS, or salinity)		10 to 1,000	mg/L	
Specific Conductivity		100 to 10,000	µs/cm	
Chloride		10 to 10,000	mg/L	
Sulfide - Pre injection	0.0	0.1 to 100	mg/L	
Sulfide - Post injection	0.0	0.1 to 100	mg/L	
B. Aquifer Matrix				
Total Iron		200 to 20,000	mg/kg	
Cation Exchange Capacity	NA	1.0 to 10	meq/100 g	
Neutralization Potential		1.0 to 100	Percent as $CaCO_3$	

NOTES:

Table S.5 Output for Substrate Requirements in Hydrogen Equivalents

Site Name: IRP Site 1 Groundwater Boundary PRB

RETURN TO COVER PAGE

1. Treatment Zone Physical Dimensions

	Values	Units	Values	Units
Width (perpendicular to groundwater flow)	200	feet	61	meters
Length (parallel to groundwater flow)	20	feet	6.1	meters
Saturated Thickness	40	feet	12.2	meters
Design Period of Performance	3	years	3	years

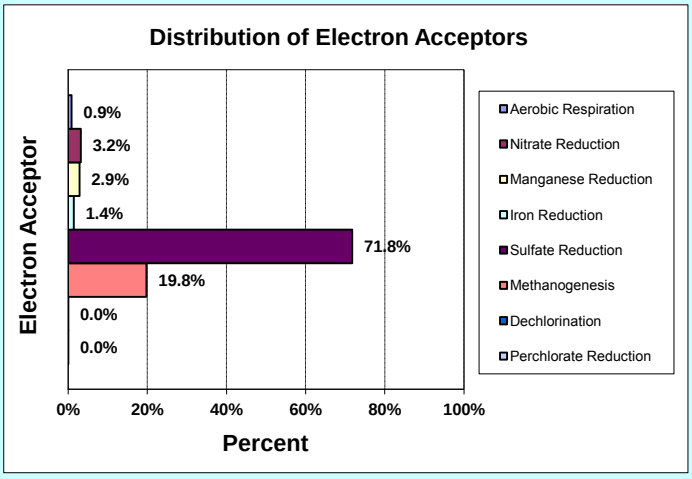
2. Treatment Zone Hydrogeologic Properties

	Values	Units	Values	Units
Total Porosity	0.35	percent	0.35	percent
Effective Porosity	0.12	percent	0.12	percent
Average Aquifer Hydraulic Conductivity	0.24	ft/day	8.5E-05	cm/sec
Average Hydraulic Gradient	0.05	ft/ft	0.05	m/m
Average Groundwater Seepage Velocity	0.10	ft/day	3.0E+00	cm/day
Average Groundwater Seepage Velocity	37	ft/yr	11.1	m/yr
Effective Treatment Zone Pore Volume	143,654	gallons	543,776	liters
Groundwater Flux (per year)	262,169	gallons/year	992,391	liters/year
Total Groundwater Volume Treated (over entire design period)	930,162	gallons total	3,520,949	liters total

3. Distribution of Electron Acceptor Demand

	Percent of Total	Hydrogen Demand (lb)
Aerobic Respiration	0.9%	1.760
Nitrate Reduction	3.2%	6.345
Sulfate Reduction	71.8%	141.419
Manganese Reduction	2.9%	5.697
Iron Reduction	1.4%	2.802
Methanogenesis	19.8%	39.004
Dechlorination	0.0%	0.021
Perchlorate Reduction	0.0%	0.008
Totals:	**100.00%**	**197.05**

Hydrogen demand in pounds/gallon:	2.12E-04
Hydrogen demand in grams per liter:	2.54E-02



4. Substrate Equivalents: Design Factor = 3.0

Product	Quantity (lb)	Quantity (gallons)	Effective Concentration (mg/L)	Effective concentration is for total volume of groundwater treated.
1. Sodium Lactate Product	27,401	2,491	1,701	as lactic acid
2. Molasses Product	20,911	1,743	1,616	as sucrose
3. Fructose Product	16,513	1,474	1,702	as fructose
4. Ethanol Product	8,443	1,224	870	as ethanol
5. Sweet Dry Whey (lactose)	13,024	sold by pound	1,175	as lactose
6. HRC®	10,012	sold by pound	1,032	as 40% lactic acid/40% glycerol
7. Linoleic Acid (Soybean Oil)	5,141	659	662	as soybean oil
8. Emulsified Vegetable Oil	8,568	1,098	662	as soybean oil

Notes:
1. Quantity assumes product is 60% sodium lactate by weight.
2. Quantity assumes product is 60% sucrose by weight and weighs 12 pounds per gallon.
3. Quantity assumes product is 80% fructose by weight and weighs 11.2 pounds per gallon.
4. Quantity assumes product is 80% ethanol by weight and weighs 6.9 pounds per gallon.
5. Quantity assumes product is 70% lactose by weight.
6. Quantity assumes HRC® is 40% lactic acid and 40% glycerol by weight.
7. Quantity of neat soybean oil, corn oil, or canola oil.
8. Quantity assumes commercial product is 60% soybean oil by weight.

Appendix B
Standard Operating Procedures

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Equipment Decontamination

Procedure 3-06

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) describes methods of equipment decontamination, used for activities where samples for chemical analysis are collected or where equipment will need cleaning before leaving a site or before use in subsequent activities.

1.2 This procedure is the Program-approved professional guidance for work performed by AECOM-Envirocon Joint Venture (AEJV) for task orders issued under the Performance Based Environmental Multiple Award Contract Number N62473-11-D-2231.

1.3 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review.

2.0 Safety

It is the responsibility of the **Site Safety and Health Officer (SSHO)** to set up the site zones (i.e., exclusion, transition, and clean) and decontamination areas. Generally the decontamination area is located within the transition zone, upwind of intrusive activities, and serves as the washing area for both personnel and equipment to minimize the spread of contamination into the clean zone. Typically, for equipment, a series of buckets are set up on a visqueen-lined bermed area. Separate spray bottles containing cleaning solvents as described in this procedure or the project Work Plan (WP) and distilled water are used for final rinsing of equipment. Depending on the nature of the hazards and the site location, decontamination of heavy equipment, such as augers, pump drop pipe, and vehicles, may be accomplished using a variety of techniques.

All **Field Personnel** responsible for equipment decontamination must adhere to the site-specific health and safety plan (SSHSP) and must wear the personal protective equipment (PPE) specified in the SSHSP. Generally this includes, at a minimum, steel-toed boots, safety glasses, American National Standards Institute (ANSI)-standard hard hats, and hearing protection (if heavy equipment is in operation). Air monitoring by the **SSHO** may result in an upgrade to the use of respirators and cartridges in the decontamination area; therefore, this equipment must be available on site. If safe alternatives are not achievable, discontinue site activities immediately.

In addition to the aforementioned precautions, the following sections describe safe work practices that will be employed.

2.1 **Chemical Hazards associated with Equipment Decontamination**

- Avoid skin contact with and/or incidental ingestion of decontamination solutions and water.
- Utilize PPE as specified in the site-specific SSHSP to maximize splash protection.
- Refer to material safety data sheets, safety personnel, and/or consult sampling personnel regarding appropriate safety measures (i.e., handling, PPE including skin and respiratory).
- Take the necessary precautions when handling detergents and reagents.

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2.2 Physical Hazards associated with Equipment Decontamination

- To avoid possible back strain, it is recommended to raise the decontamination area 1 to 2 feet above ground level.
- To avoid heat stress, over exertion, and exhaustion, it is recommended to rotate equipment decontamination among all site personnel.
- Take necessary precautions when handling field sampling equipment.

3.0 Terms and Definitions

None.

4.0 Training and Qualifications

4.1 The **Project Manager (PM)** is responsible for ensuring that decontamination activities comply with this procedure. The **PM** is responsible for ensuring that all personnel involved in equipment decontamination shall have the appropriate education, experience, and training to perform their assigned tasks.

4.2 The **Program Quality Control Manager** is responsible for ensuring overall compliance with this procedure.

4.3 The **Field Manager** is responsible for ensuring that all field equipment is decontaminated according to this procedure.

4.4 All **Field Personnel** are responsible for the implementation of this procedure.

5.0 Procedure

Decontamination of equipment used in soil/sediment sampling, groundwater monitoring, well drilling and well development, as well as equipment used to sample groundwater, surface water, sediment, waste, wipe, asbestos, and unsaturated zone, is necessary to prevent cross-contamination and to maintain the highest integrity possible in collected samples. Planning a decontamination program requires consideration of the following factors:

- Location where the decontamination procedures will be conducted
- Types of equipment requiring decontamination
- Frequency of equipment decontamination
- Cleaning technique and types of cleaning solutions appropriate to the contaminants of concern
- Method for containing the residual contaminants and wash water from the decontamination process
- Use of a quality control measure to determine the effectiveness of the decontamination procedure

The following subsections describe standards for decontamination, including the frequency of decontamination, cleaning solutions and techniques, containment of residual contaminants and cleaning solutions, and effectiveness.

5.1 Decontamination Area

Select an appropriate location for the decontamination area at a site based on the ability to control access to the area, the ability to control residual material removed from equipment, the need to store clean equipment, and the ability to restrict access to the area being investigated. Locate the decontamination area an adequate distance away and upwind from potential contaminant sources to avoid contamination of clean equipment.

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5.2 Types of Equipment

Drilling equipment that must be decontaminated includes drill bits, auger sections, drill-string tools, drill rods, split barrel samplers, tremie pipes, clamps, hand tools, and steel cable. Decontamination of monitoring well development and groundwater sampling equipment includes submersible pumps, bailers, interface probes, water level meters, bladder pumps, airlift pumps, peristaltic pumps, and lysimeters. Other sampling equipment that requires decontamination includes, but is not limited to, hand trowels, hand augers, slide hammer samplers, shovels, stainless-steel spoons and bowls, soil sample liners and caps, wipe sampling templates, composite liquid waste samplers, and dippers. Equipment with a porous surface, such as rope, cloth hoses, and wooden blocks, cannot be thoroughly decontaminated and shall be properly disposed of after one use.

5.3 Frequency of Equipment Decontamination

Decontaminate down-hole drilling equipment and equipment used in monitoring well development and purging prior to initial use and between each borehole or well. Down-hole drilling equipment, however, may require more frequent cleaning to prevent cross-contamination between vertical zones within a single borehole. When drilling through a shallow contaminated zone and installing a surface casing to seal off the contaminated zone, decontaminate the drilling tools prior to drilling deeper. Initiate groundwater sampling by sampling groundwater from the monitoring well where the least contamination is suspected. Decontaminate groundwater, surface water, and soil sampling devices prior to initial use and between collection of each sample to prevent the possible introduction of contaminants into successive samples.

5.4 Cleaning Solutions and Techniques

Decontamination can be accomplished using a variety of techniques and fluids. The preferred method of decontaminating major equipment, such as drill bits, augers, drill string, and pump drop-pipe, is steam cleaning. To steam clean, use a portable, high-pressure steam cleaner equipped with a pressure hose and fittings. For this method, thoroughly steam wash equipment and rinse it with potable tap water to remove particulates and contaminants.

A rinse decontamination procedure is acceptable for equipment such as bailers, water level meters, new and re-used soil sample liners, and hand tools. The decontamination procedure shall consist of the following: (1) wash with a non-phosphate detergent (Alconox®, Liquinox®, or other suitable detergent) and potable water solution; (2) rinse with potable water; (3) spray with laboratory-grade isopropyl alcohol; (4) rinse with deionized or distilled water; and (5) spray with deionized or distilled water. If possible, disassemble equipment prior to cleaning. Add a second wash at the beginning of the process if equipment is very soiled.

Decontaminating submersible pumps requires additional effort because internal surfaces become contaminated during usage. Decontaminate these pumps by washing and rinsing the outside surfaces using the procedure described for small equipment or by steam cleaning. Decontaminate the internal surfaces by recirculating fluids through the pump while it is operating. This recirculation may be done using a relatively long (typically 4 feet) large-diameter pipe (4-inch or greater) equipped with a bottom cap. Fill the pipe with the decontamination fluids, place the pump within the capped pipe, and operate the pump while recirculating the fluids back into the pipe. The decontamination sequence shall include: (1) detergent and potable water; (2) potable water rinse; (3) potable water rinse; and (4) deionized water rinse. Change the decontamination fluids after each decontamination cycle.

Solvents other than isopropyl alcohol may be used, depending upon the contaminants involved. For example, if polychlorinated biphenyls or chlorinated pesticides are contaminants of concern, hexane may be used as the decontamination solvent; however, if samples are also to be analyzed for volatile organics, hexane shall not be used. In addition, some decontamination solvents have health effects that must be considered. Decontamination water shall consist of distilled or deionized water. Steam-distilled water shall not be used in the decontamination process as this type of water usually contains elevated

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concentrations of metals. Decontamination solvents to be used during field activities will be specified in the project WP.

Rinse equipment used for measuring field parameters, such as pH (indicates the hydrogen ion concentration – acidity or basicity), temperature, specific conductivity, and turbidity with deionized or distilled water after each measurement. Also wash new, unused soil sample liners and caps with a fresh detergent solution and rinse them with potable water followed by distilled or deionized water to remove any dirt or cutting oils that might be on them prior to use.

5.5 Containment of Residual Contaminants and Cleaning Solutions

A decontamination program for equipment exposed to potentially hazardous materials requires a provision for catchment and disposal of the contaminated material, cleaning solution, and wash water.

When contaminated material and cleaning fluids must be contained from heavy equipment, such as drill rigs and support vehicles, the area must be properly floored, preferably with a concrete pad that slopes toward a sump pit. If a concrete pad is impractical, planking can be used to construct solid flooring that is then covered by a nonporous surface and sloped toward a collection sump. If the decontamination area lacks a collection sump, use plastic sheeting and blocks or other objects to create a bermed area for collection of equipment decontamination water. Situate items, such as auger flights, which can be placed on metal stands or other similar equipment, on this equipment during decontamination to prevent contact with fluids generated by previous equipment decontamination. Store clean equipment in a separate location to prevent recontamination. Collect decontamination fluids contained within the bermed area and store them in secured containers as described below.

Use wash buckets or tubs to catch fluids from the decontamination of lighter-weight drilling equipment and hand-held sampling devices. Collect the decontamination fluids and store them on site in secured containers, such as U.S. Department of Transportation-approved drums, until their disposition is determined by laboratory analytical results.

6.0 Quality Control and Assurance

A decontamination program must incorporate quality control measures to determine the effectiveness of cleaning methods. Quality control measures typically include collection of equipment blank samples or wipe testing. Equipment blanks consist of analyte-free water that has been poured over or through the sample collection equipment after its final decontamination rinse. Wipe testing is performed by wiping a cloth over the surface of the equipment after cleaning. These quality control measures provide "after-the fact" information that may be useful in determining whether or not cleaning methods were effective in removing the contaminants of concern.

7.0 Records, Data Analysis, Calculations

Any project where sampling and analysis is performed shall be executed in accordance with an approved sampling and analysis plan. This procedure may be incorporated by reference or may be incorporated with modifications described in the plan.

Deviations from this procedure or the sampling and analysis plan shall be documented in field records. Significant changes shall be approved by the **Program Quality Control Manager**.

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8.0 Attachments or References

8.1 ASTM Standard D5088. 2008. *Standard Practice for Decontamination of Field Equipment Used at Waste Sites.* ASTM International, West Conshohocken, PA. 2008. DOI: 10.1520/D5088-02R08. www.astm.org.

8.2 NAVSEA T0300-AZ-PRO-010. *Navy Environmental Compliance Sampling and Field Testing Procedures Manual*. August 2009.

Author	*Reviewer*	*Revisions (Technical or Editorial)*
Phil Granger, Field Manager	Chris Barr, Program Quality Control Manager	Rev 0 – Initial Issue

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Monitoring/Injection Well Drilling, Installation and Abandonment

Procedure 3-12

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) describes the methods and procedures used during the drilling, installation and abandonment of groundwater injection and monitoring wells. It describes the components of well design and installation and sets forth the rationale for use of various well installation techniques in specific situations.

1.2 This procedure is the Program-approved professional guidance for work performed by AECOM-Envirocon Joint Venture (AEJV) for task orders issued under the Performance Based Environmental Multiple Award Contract Number N62473-11-D-2231.

1.3 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review.

2.0 Safety

Field personnel shall perform work in accordance with the site-specific health and safety plan (SSHSP). During well installation, subcontractors in direct contact with potentially contaminated media shall wear the proper personal protective equipment (PPE) as outlined in the SSHSP. Failure to comply will result in disciplinary action. In addition, all drill rigs shall ensure that a guard is in place around the auger (physical guard around the auger; barricade around the perimeter of the auger; or electronic brake activated by a presence-sensing device) to guard against employee contact with the auger.

If circumstances warrant, a real-time immediate response instrument, such as a Miniram Dust Monitor, organic vapor analyzer, HNu, Thermo, Draeger or Sensidyne tubes, or explosimeter, will be used to monitor the work area. When real/time instrument response exceeds the permissible exposure limit, **personnel** shall don the appropriate PPE and alternate control measures to ensure personnel safety. If safe control measures are not achievable, field activities shall be discontinued **immediately.**

Depending upon the type of contaminant expected, the following subsections describe safe work practices to be employed.

2.1 **General Procedures**

- Conduct subsurface utility clearance before any subsurface activities begins. Use the regional utility clearance hotline as well as a private utility locating service.
- Check for, and avoid any overhead utilities before setting drill rigs at any well locations.
- Avoid skin contact with and/or incidental ingestion of soil cuttings.
- Utilize protective clothing, steel-toed boots, gloves, hearing protection, and safety glasses as warranted.
- Stand upwind of the borehole, and/or use respiratory protection to avoid breathing constituents vented from the boring.
- Set up site control around the drill rig to keep unnecessary personnel from entering the drilling area.

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2.2 **Flammable or Explosive Conditions**

- If warranted, monitor explosive gases as continuously as possible using an explosimeter and oxygen meter.
- Place all ignition sources upwind or crosswind of the borehole.
- If explosive gases exceed the designated action levels as specified in the site-specific HSP, cease operations and evaluate conditions.

2.3 **Physical Hazards associated with Well Installation**

- To avoid lifting injuries associated with hollow-stem continuous-flight auger use and general well installation practices, use the large muscles of the legs, not the back. Use mechanical means of lifting whenever possible.
- Stay clear of all moving equipment and avoid wearing loose fitting clothing.
- When using cutting devices, cut away from self.
- To avoid slip/trip/fall conditions as a result of drilling activities, keep the area clear of excess soil cuttings and use textured boots/boot cover bottoms in muddy areas. Practice good housekeeping procedures in and around all work and staging areas.
- To avoid heat/cold stress as a result of exposure to extreme temperatures and PPE, drink electrolyte replacement fluids (1 to 2 cups per hour is recommended) and, in cases of extreme cold, wear fitted insulating clothing.
- Be aware of restricted mobility caused by PPE.

3.0 Terms and Definitions

3.1 **Filter Pack:** Filter pack is sand or gravel that is smooth, uniform, clean, well-rounded, and siliceous. It is placed in the annulus of the well between the borehole wall and the well screen to prevent formation materials from entering the well and to stabilize the adjacent formation.

3.2 **Annulus:** The annulus is the down hole space between the borehole wall and the well casing and screen.

3.3 **Bridge:** A bridge is an obstruction in the drill hole or annulus. A bridge is usually formed by caving of the wall of the well bore, by the intrusion of a large boulder, or by filter pack materials during well completion. Bridging can also occur in the formation during well development.

3.4 **Grout:** Grout is a fluid mixture of cement and water that can be forced through a pipe and emplaced in the annular space between the borehole and casing to form an impermeable seal. Various additives, such as sand, bentonite, and polymers, may be included in the mixture to meet certain requirements.

3.5 **Sieve Analysis:** Sieve analysis is the evaluation of the particle-size distribution of a soil, sediment, or rock by measuring the percentage of the particles that will pass through standard sieves of various sizes.

4.0 Training and Qualifications

4.1 **Project Managers (PMs)** are responsible for issuing work plans (WPs) that reflect the procedures and specifications presented in this procedure. Individual municipalities, county agencies, and possibly state regulatory agencies enforce regulations that may include well construction and installation requirements. The **PM** shall be familiar with current local and state regulations, and ensure that these regulations are followed. Regulations are subject to constant revision. Every effort should be made to stay informed of these changes through contact with the agencies that oversee work in specific project areas, prior to initiation of field activities. The **PM** or **designee** shall review all well construction logs on a minimum

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monthly basis. The **PM** is responsible for ensuring that all personnel involved in monitoring well installation and abandonment shall have the appropriate education, experience, and training to perform their assigned tasks.

4.2 The **Program Quality Control Manager** is responsible for ensuring overall compliance with this procedure.

4.3 The **Field Manager** is responsible for direct supervision of the installation of monitoring wells and ensuring that procedures and specifications in the field are properly and safely implemented. The qualifications for the **Field Manager** include a degree in geology, hydrogeology, environmental science, or civil/geotechnical/environmental engineering with at least 2 years of field experience in the installation of monitoring wells. The Field Manager must have completed the 30-hour OSHA construction training.

4.4 All **field personnel** are responsible for the proper and safe implementation of this procedure. **Field personnel** must have completed the 40-hour HAZWOPER training and be up to date on annual refresher courses. **Field personnel** must be currently enrolled in a medical monitoring program.

4.5 The **Field Manager** or **designee** is expected to obtain a description of the lithologic samples obtained during the borehole drilling and construction of each well. These data are often required to provide guidance regarding the installation of specific components of the well.

5.0 Equipment and Supplies

5.1 CME 85 or CMW 95 Hollow Stem Auger drill rig: Truck or track mounted drill rig capable of advancing hollow stem augers to desired depths. Fitted with a manual or auto-hammer to collect undisturbed split-spoon samples ahead of the drill bit.

5.2 Direct Push drill rig: Truck or track mounted direct push drill rig capable of advancing 2.25-inch drill rods to the desired depth.

5.3 Emulsified Vegetable Oil or similar subsurface biological amendment:

6.0 Calibration or Standardization

7.0 Procedure

7.1 Well Design Considerations

The following information is compiled from a number of technical references. For additional information related to well installation, consult the references listed in the last section of this procedure.

7.1.1 Well Placement

The location of monitoring and injection wells should be determined during the development of the work plan. Changes in well locations may have to be made in the field based upon underground and overhead utility locations, topographic features and site access issues. Any changes to well locations should be discussed with the project team.

7.1.2 Well Depth and Screened Interval

Well Depths and screened intervals for monitoring and injection wells should be determined during the development of the work plan. Based upon subsurface conditions encourtered during drilling, the well depths and screen intervals may need to be adjusted and should be discussed with the project team before permanent decisions are made.

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7.1.3 Well Permitting

All wells shall be permitted in accordance with the regulations of the local jurisdiction where well installation is occurring. Contact local authorities prior to establishing well construction requirements for the project.

The permit procedure may require permit fees, site inspections, and an application signed by a **registered professional geologist** or **engineer**. Permit requirements may affect field schedules and budgets. The **driller** may also be required by law to be licensed and bonded. Provide documentation that all legal requirements have been met to the appropriate agencies prior to the drilling and installation of monitoring and injection well.

7.2 Selection of Drilling Method

There are a number of different drilling methods that may be employed for the installation of monitoring and injection wells. Drilling methods should be established during the development of the work plan based upon the depth and location of the well, subsurface conditions and regulatory requirements. Conditions encountered during drilling may limit the depth of borehole advancement, and a change in the drilling method may be needed. Any changes in the drilling method should be discussed with the project team. Technical, budgetary and regulatory requirements should be considered before any changes are made.

The following subsections discuss commonly used drilling methods and their applicability to installation of monitoring wells. Regardless of the drilling method selected, decontaminate all drilling equipment using Procedure 3-06, *Equipment Decontamination*. Follow these procedures before use and between borehole locations to prevent cross-contamination. In addition to selecting the proper drilling technique, take other precautions to prevent distribution of any existing contaminants throughout the borehole or across different water bearing units.

7.2.1 Hollow-Stem Continuous-Flight Auger

HSA is the most frequently employed method used in the environmental industry for the drilling and installation of shallow wells in unconsolidated materials. Drilling with HSA is possible in loose sand and gravel, loose boulders in alluvium, clay, silt, shale, and sandstone. HSA drilling is usually limited to unconsolidated materials and depths of approximately 150 to 200 feet. HSA drill rigs are mobile, relatively inexpensive to operate, generally cause minimal disturbance to the subsurface materials, and have the additional advantage of not introducing drilling fluids (e.g., air, mud, or foam) to the formation.

Another advantage of the HSA method is that undisturbed samples are obtained by driving a split-spoon sampler below the lead drill bit. Soil samples can usually be easily collected in this manner with a minimum of tripping sampling tools into and out of the hole.

Moreover, in the HSA drilling method, the well is constructed inside the HSAs as the augers are gradually removed from the ground. This method decreases the possibility of the borehole collapsing before the well is installed. HSAs shall have a nominal outside auger-flight diameter of 10 to 12 inches and a minimum inside diameter of 8 inches. Larger inside diameter auger flights are sometimes available. Well casing diameter is usually limited to 4 inches or less when using the HSA method. The difference between the inner diameter (I.D.) of the auger and the outer diameter (O.D.) of the well casing shall be at least 4 inches (i.e., a minimum 2-inch annular space) to permit effective placement of filter pack, bentonite seal, and grout without bridging.

7.2.2 Direct Push

Direct push methods for monitoring and injection well installation are limited to use in unconsolidated formations such as alluvial/stream sediments, glacial deposits, and loose sediments. Direct push methods are generally successful at penetrating clays, silts, sands and some gravel to depths ranging from 50 to 75 feet bgs. Direct push methods are not designed for penetration of consolidated bedrocks.

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Direct push drilling involves driving steel rods through the subsurface using a truck mounted vibratory percussion hammer. The rods are typically hollow and can be driven using a solid fixed tip to push soil aside producing no soil cuttings, or using a retractable tip that allows continuous soil cores to be collected during drilling to depth, removing all soil from the borehole.

The direct push rods usually must be removed before well installation, which could cause borehole collapse in looser formations. Direct push technology is typically the fastest and least expensive method of drilling, but well sizes are limited to 2-inch OD or less, and there are depth limitations.

For the purposes of substrate injection the direct push rig can advance drill rods to the desired depth, pull back on the drill rod string to expose the sampling/injection screen, and inject substrate into the subsurface through the drill rods, under pressure. This procedure allows a one-time injection without the costs associated with a permanent well construction and subsequent abandonment.

7.3 Monitoring Well Design Procedures

Discussion of the design of the individual components of a typical monitoring well is given in the following subsections.

7.3.1 Pre-Installation Design Drawing

Develop a pre-installation design drawing before the borehole for the well is drilled, and borehole-specific lithologic and hydrologic information are available. The pre-installation design should be based on previous borings and other site specific data that is available. The pre-design drawing shall identify the anticipated depth of the well, the locations of the top and bottom of the screened interval, the anticipated top of the filter pack, the anticipated top of the bentonite seal, and the locations of centralizers (if applicable). In addition, calculate the volumes of sand, bentonite, and grout anticipated to be placed in the annular space of the well. Maintain the drawing as documentation of the well design. Based upon the subsurface conditions during drilling the well design may need to be modified at the time of installation. Any changes to the well design should be discussed with the project team and regulators before well installation proceeds.

7.4 Monitoring/Injection Well Installation Techniques

The following general procedures describe the installation of injection or groundwater monitoring wells.

7.4.1 General Casing and Screen Installation Techniques

Following completion of the borehole, the **Field Manager** or **designee** will first measure the total depth of the borehole to ensure that the desired depth has been attained. The lengths of casing and screen shall also be measured. These measurements shall be made with an accuracy of 0.01 feet using either a fiberglass or steel tape measure.

Installation of the casing and screen is normally accomplished by emplacing them into the borehole as an integral unit. Prior to installation, decontaminate individual lengths of the well casing and screen according to Procedure 3-06, *Equipment Decontamination*, unless the casing and screen were certified by the manufacturer to have been properly pre-cleaned at the factory and sealed in plastic. Following decontamination, inspect each length to ensure that damaged or otherwise unsuitable sections are not used.

To ensure even distribution of filter pack, bentonite seal, and grout materials around the well within the borehole, suspend the casing and screen with a threaded hoisting plug and do not allow them to rest on the bottom of the boring unless the installation is less than 30 feet deep.

A clamp may be used to hold the well string at the surface so the hoisting plug can be removed as additional screen or casing pieces are added during installation. The length of the clamp must be wider than the borehole diameter and have a solid, stable platform to rest upon during construction of the well.

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7.4.2 Centralizers

Install centralizers at the top and bottom of screened sections when using the air or mud rotary techniques for well installation. Also place centralizers at 20- to 40-foot intervals on blank casing; the **Field Manager** will determine the spacing according to the depth of the well. Align the centralizers from top to bottom of the casing so that they do not interfere with the insertion and removal of the tremie pipe and measuring tape. All devices used to affix centralizers to the casing shall not puncture the casing or contaminate the groundwater with which they come in contact. Centralizers shall be constructed of stainless steel.

7.4.3 Filter Pack Installation

Prior to the addition of any filter pack material, cover the top of the well casing to prevent filter pack material from entering it.

The filter pack is usually installed through HSAs, conductor casing, or a tremie pipe depending on the drilling technique used; however, if the depth to the bottom of the screened interval is less than 10 feet and lithologic materials are sufficiently consolidated to preclude the possibility of hole collapse, the filter pack may be poured into the annular space of the well from the ground surface. This procedure applies to any drilling method.

During installation, measure the level of the top of the filter pack periodically to ensure that no bridging has occurred, and to determine the depth to the top of the filter pack. Be sure that the filter pack encloses the entire length of the screened section. For wells less than 100 feet in total depth, the filter pack shall generally extend to 2 feet above the top of the screened section of the well. For wells greater than 100 feet in total depth, an additional 1 foot of filter pack may be emplaced above the screen for each 100 feet of well depth.

Following the installation of the filter pack, a surge block or large bailer shall be moved up and down the length of the screen interval for approximately 10 minutes to set and compact the filter pack and to begin well development. After surging the well, check the level of the filter pack again. Add more filter pack material according to the procedures described above if any settling of the filter pack has occurred, and repeat the surging process to set the additional filter pack. After emplacement, note the volume of filter pack material placed in the well, record it in the well completion record (Figure 3-12-1), and compare it to the calculated volume of filter pack that was expected to have been used. Record the depth to the top of the filter pack from the ground surface.

7.4.4 Annular Seal Installation

The sodium bentonite transition seal shall have a minimum thickness of 3 feet. It may be constructed of powdered, granular, or pelletized bentonite, and may be emplaced as a dry solid, powder, or slurry. Use only sodium bentonite manufactured specifically for use in the drilling and construction of water wells. Typically, granular or pelletized bentonite is emplaced dry. Powdered bentonite is usually mixed with potable water to produce slurry. Depending on the type of installation method, the bentonite may be emplaced through the HSAs, conductor casing, or tremie pipe.

In dry form, place the bentonite directly on the top of the filter pack. After emplacing each 1-foot-thick layer of dry bentonite in the well, add approximately 5 gallons of water of known chemical quality to hydrate the bentonite. Allow a minimum of 15 minutes for hydration of the bentonite seal once it has been completely installed.

When emplacing the bentonite in slurry form, take care that the bentonite is thoroughly mixed, with no visible lumps, to ensure the proper consistency. Before placement of the seal, place a 1-foot layer of fine-grained silica sand over the top of the filter pack. This fine-grained sand layer will prevent invasion of the filter pack by the bentonite slurry.

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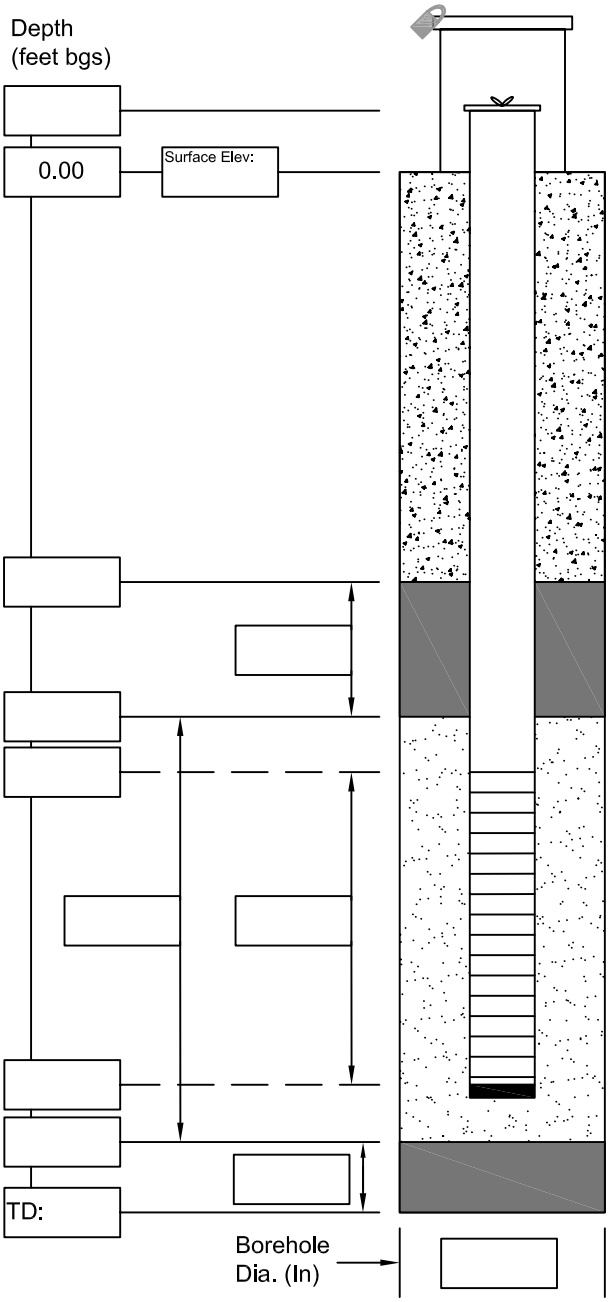
Monitoring/Injection Well Construction Log

Project Name:	Project Number:	
Project address:	Well ID:	Sheet_____of_____
Drillers name:	Borehole Diameter (in):	Total Depth (ft bgs):
Drilling Company:	Date Started:	Approx. Depth to Water (ft bgs):
Drilling Equipment:	Date Completed:	TOC Elevation and Datum:
Drilling Method:	Logged by:	Northing and Datum:
Drilling Fluid:	Checked by:	Easting and Datum:



Protective Casing
Material/Type: _____
Diameter: _____

Guard Posts (Y/N)

Surface Pad
Type: _____

Well Casing
Type: _____
Diameter: _____
Interval BGS: _____

Well Casing Screen
Type: _____
Diameter: _____
Slot Size and Type: _____
Interval BGS: _____

Sanitary Seal/Cement
Type: _____
Interval BGS: _____
Quantity: _____
Tremied (Y/N)

Centralizers
Depth: _____

Bentonite Seal
Type: _____
Setup/Hydration time: _____
Interval BGS: _____
Quantity: _____
Tremied (Y/N)

Filter Pack
Type: _____
Interval BGS: _____
Quantity: _____
Tremied (Y/N)

Bottom Cap
Type: _____
Interval BGS: _____

Bottom Bentonite Seal
Type: _____
Setup/Hydration time: _____
Interval BGS: _____
Quantity: _____
Tremied (Y/N)

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Following the emplacement of the transition bentonite seal, emplace the remaining annular seal. The annular seal shall be slurry consisting of 7 to 9 gallons of water per 94-pound bag of Portland cement Type I or II and a minimum of 3 to 5 percent bentonite (1/4 to 1/2 bags of bentonite powder per five bags of Portland cement). The slurry may be emplaced through an HSA, conductor casing, or tremie pipe, depending on the method of installation. Thoroughly mix the grout to ensure the proper consistency with no visible lumps of dehydrated powder. The rates at which the augers or pipe are withdrawn and the slurry added will be such that the level of the grout within the well annulus is just below the lowermost auger or pipe.

If a tremie pipe is used, emplace the annular grout seal by pumping through a pipe with a minimum 1-inch I.D., in one continuous pour, from the top of the transition seal to the ground surface. Place the bottom of the tremie pipe about 5 to 10 feet above the transition seal, depending on the stability of the hole and impact velocity of the grout.

A tremie pipe is not required for annular seals less than 10 feet from the ground surface to the top of the transition seal or for grouting within dual wall drill strings or HSAs. Measure the volume of grout seal material placed in the well, record it in the well construction log, and compare it with the calculated volume. The slurry shall extend from the top of the bentonite seal to a depth of approximately 2 feet below ground surface (bgs).

7.4.5 Annular Seal "Set Time" and Setting

Let the annular grout seal set at least 12 hours before disturbing the casing or well so that separations or breaks do not occur between the seal and the casing, or between the seal and the borehole. Development of the well is prohibited until the grout seal has set. Likewise, the concrete slab, traffic box, and/or casing riser of the surface completion shall not be poured and constructed until the grout seal has set. Top off any settlement of the grout seal as soon as possible after it sets. Record all pertinent data on the well construction log.

7.4.6 Surface Completion

The surface of a groundwater monitoring well shall be either an aboveground completion or as a flush-to-ground completion. Regardless of the method, each monitoring well shall have, at a minimum, a casing cap, concrete slab and annular seal, and a locking protective casing or locking vault.

In an aboveground completion, the protective casing or monument is installed around the top of the well casing within a cement surface seal. A 2-foot-long by 2-foot-wide cement pad with a minimum thickness of 3 inches is constructed around the protective casing. Type 1 Portland cement, which meets the requirements of Class A standards, is used for the surface seal. Inspect the monument prior to installation to ensure that no oils, coatings, or chemicals are present. Once installed, maintain the monument in a plumb position with 2 to 3 inches of clearance between the top of the well casing and the lid of the monument. The monument shall extend at least 18 inches above grade and at least 12 inches below grade. In areas where frost heaving is considered a factor, the casing shall extend below the frost depth. Construct a minimum of three concrete-filled posts around the well to protect it from vehicular damage.

Inside the monument, cut or scribe two permanent survey marks, approximately 0.25 inches apart, into the top of the well casing and permanently mark the well with its identification number. Cover the top of the well casing with a slip cap or locking cap to prevent debris from entering the well. Fit the monument with a casehardened lock to prevent unauthorized entry.

In a flush-to-ground completion, the protective casing or traffic box is installed around the top of the well casing, which has been cut off slightly below grade. The traffic box has a lid that is held firmly in place by bolts and has a flexible O-ring or rubber gasket to prevent water from entering the box. The traffic box is set within a cement surface seal slightly above grade to deflect surface water flow away from the well. The surface seal extends to a minimum of 4 inches from the outer rim of the traffic box. Type 1 Portland cement, which meets the requirements of Class A standard, is used for the surface seal. Inspect the

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traffic box prior to installation to ensure that no oils, coatings, or chemicals are present. Once installed, maintain the traffic box in a level position that leaves 2 to 3 inches of clearance between the top of the well casing and the lid of the traffic box.

Cut two permanent survey marks into the top of the well casing approximately 0.25 inches apart and permanently mark the well with its identification number. Cover the top of the well casing with a lockable cap to prevent debris from entering the well. Also, fit the lockable cap with a casehardened lock to prevent unauthorized entry.

7.4.7 Installation of Surface Casing

The use of surface casing may be required to minimize the potential for cross-contamination of different hydrogeologic zones within the subsurface of a site. The depth of placement of the surface casing shall be based on site-specific geologic knowledge obtained from lithologic samples collected in situ during the drilling of the well boring.

If a surface casing is to be installed permanently along with the well, grout it in place. The borehole shall be of sufficient diameter that a tremie or grout pipe can be easily placed between the borehole wall and the outside of the surface casing. After the desired placement depth is reached and the drilling tools are removed from the borehole, lower the casing into the borehole and center it. The bottom of the surface casing may be plugged or driven into the sediment at the base of the borehole to keep grout from entering the casing, if necessary.

Install grout through the tremie pipe and pump it from the bottom of the casing to ground surface. As the grout is being placed, raise the tremie pipe slowly to avoid excessive backpressure and potential clogging of the tremie pipe. After the grout has been allowed to set for at least 24 hours, drilling and subsequent well installation can continue. The required time for grout to set before drilling can continue depends on the volume of grout emplaced; the more grout used, the longer the delay time.

7.4.8 Well Construction Recordkeeping Procedures

A written well completion record (Figure 3-12-1) detailing the depths, timing, amount of materials, and methods of installation/construction for each step of monitoring well construction shall be prepared during construction of each monitoring well by the **Field Manager** or **designee**. Construction records shall be kept in a hardbound field notebook dedicated to the CTO. An “as-built” drawing illustrating the placement location and amounts of all materials used in construction of each monitoring well shall be prepared in the field at the time of construction. The well construction record shall be filled out with indelible ink. Construction records shall include the date/time and quantities of materials used at each of the following stages of monitoring well construction, including:

- Drilling
  - Drill rig type
  - Drilling method/coring method
  - Drill bit/core barrel diameter (hole diameter)
  - Drill company, driller, helper(s)
  - Field geologist, supervising geologist
  - Dates/times start and finish drilling hole, interval drilling rates
  - Total depth of hole
  - Drilling location, surveyed ground elevation
  - Inclination of hole from horizontal
- Borehole abandonment – type, volume, and surface seal

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- Casing material
  - Type
  - Top and bottom of section as actually installed
  - Length
  - Depth Interval
- Casing decontamination – document process and equipment used
- Casing diameter – nominal I.D. of casing
- Screen material
  - Type
  - Top and bottom of section as actually installed
  - Length
  - Depth Interval
  - Slot type, size, shape
  - Type of bottom plug and/or cap used
- Filter pack material
  - Composition and size gradation
  - Manufacturer
  - Actual volume and depth of top and bottom of filter pack
  - Calculated volume versus actual volume used and explanation of discrepancies
- Transition seal
  - Composition and depth of top and bottom of seal
  - Size (or gradation) or material used (e.g., pellets, granulated, or powdered)
  - Time allowed for hydration prior to emplacement of annular grout slurry seal
- Annular slurry seal
  - Date and time of beginning and completion of annular seal
  - Type, depth interval, and actual volume of seal
  - Calculated volume versus actual volume and explanation of discrepancies
  - Set time allowed prior to commencement of additional work
- Surface completion
  - Type of construction
  - Nature of materials used for surface completion
  - Date/time of completion

7.4.9 Well Location

A **registered land surveyor** shall survey each monitoring well location for exact horizontal location to the nearest 0.5 foot, and exact vertical location to the nearest 0.01 foot, referenced to mean sea level or mean low low water. The vertical elevation shall be surveyed between the two notches cut in the top of

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the well casing, which is the point from which all water level measurements shall be made. The elevation of the ground or top of the concrete slab adjacent to the monitoring well shall also be surveyed, to the nearest 0.01 foot.

7.5 Well Abandonment/Destruction

Once a monitoring well is no longer needed as part of an investigation, or has been damaged to the extent that it cannot be repaired, it is essential that it be properly abandoned. The proper abandonment of a monitoring well ensures that the underlying groundwater supply is protected and preserved. In addition, proper well abandonment eliminates a potential physical hazard and liability. An additional permit and/or inspection may be required for abandonment.

The standard procedures for the abandonment of a groundwater monitoring well apply to the HSA drilling method. This type of installation was chosen because it is the primary method of abandoning groundwater monitoring wells.

The first step in abandoning a groundwater monitoring well is to remove the surface completion from around the top of the well casing. This is normally accomplished using a jackhammer to break the surface cement seal, and then removing the monument or traffic box. When the surface seal and the wellhead cover have been removed, over-drill the well to its total depth using HSAs. Once the total depth of the well has been reached, remove the casing and screen from the borehole. Then completely backfill the borehole with a grout seal. Typically, the grout seal is emplaced as slurry of Portland cement grout, which contains a minimum of 3 to 5 percent bentonite as described in Section 7.4.5 When mixing the slurry, take care that the bentonite is mixed according to the manufacturer's specifications to ensure the proper consistency.

Emplace the slurry through the HSAs. The rates at which the augers are withdrawn and the slurry is added shall be such that the level of the slurry within the borehole is just below the lead auger. The borehole seal shall extend from the total depth of the borehole to a depth of approximately 1 foot bgs. Then repair the surface to prior conditions and grade.

If the monitoring well casing cannot be pulled or drilled out, perforate the well casing adjacent to the saturated zones so that the annular space and any nearby voids can be filled with sealing material. Fill the perforated well or borehole from the bottom up with an appropriate sealing material, such as neat cement. Inject the neat cement under pressure to force it into the annular space, nearby voids, and filter pack. Apply pressure for a sufficient time to allow the cementing mixture to set. After the cement has hardened, excavate a hole around the well with a backhoe to the depth specified in the Monitoring Well Abandonment Work Plan and ensure the excavation depth is in accordance with local regulatory agency guidelines. Remove the uppermost portion of the casing, (if still in place), and pour a cement cap on top of the abandoned well, and backfill the remaining portion of the excavation with sealing material. Note, if **personnel** are required to enter the excavation to remove the upper portion of the casing, then proper sloping and shoring are required as per Section 25, *Excavation and Trenching*, of Safety – Safety and Health Requirements, EM 385-1-1 (USACE 2008).

7.6 Vapor Extraction/Monitoring Wells

Vapor extraction/monitoring wells have most of the same design and installation considerations and procedures as groundwater monitoring wells, with the exception that they are screened in the unsaturated zone. Vapor extraction/monitoring wells generally shall not be screened over an interval greater than 20 feet and shall not be screened over two or more lithologies that have air permeabilities that differ by more than one order of magnitude. Vapor extraction/monitoring wells shall be installed using drilling techniques that do not require drilling fluids other than filtered air. Vapor monitoring wells may have casing I.D.s of 2 inches or less while extraction wells shall generally have casing I.D.s of at least 4 inches. The design of vapor extraction/monitoring wells is dependent upon many site-specific factors, such as the depth of contamination, soil conditions, geology, and depth to groundwater. As a

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result, specifics related to the design of these wells shall be included in the project WP, sampling and analysis plan, or plans and specifications.

7.7 Drive Points

An alternative to conventional monitoring well construction is, under limited conditions, the use of drive points. These consist of slotted steel pipe that is pushed, hammered, or hydraulically jetted into the ground. A filter pack is not constructed around the screen, so the width of the screen openings must be sufficiently small to prevent the passage of significant quantities of sediment into the well during the withdrawal of water for sampling. In some instances, the drive points are used only as piezometers.

Drive points are commonly used in hazardous waste investigations to sample ambient soil gases in the vadose zone. It is often possible to extend the drive point below the water table to collect water samples. Drive points may also be used as temporary injection wells for subsurface substrate injections. In some instances, permits may be required because the drive points are considered in some jurisdictions to be equivalent to a temporary monitoring well.

7.8 Hydropunch Sampling

Another alternative to conventional monitoring well construction is the use of a discrete groundwater sampling device known as a Hydropunch. The Hydropunch tool can be used in conjunction with a standard drill rig, a cone penetrometer rig, or possibly a vehicle capable of driving vapor probes to sample groundwater and non-aqueous phase liquid in unconsolidated formations. The Hydropunch tool is constructed of a stainless steel drive point, a perforated section of Teflon pipe for a sample intake, and a stainless steel sample chamber. The tool is 55.5 inches long, 2 inches in O.D., and weighs approximately 24 pounds.

Ideally, a standard HSA drill rig is used to drill a pilot hole to a depth just above the desired sampling depth. The Hydropunch tool is then hydraulically pushed or driven 4 to 5 feet through the saturated zone at each sampling location. As the tool is advanced, the sample intake screen remains pristine within the watertight stainless steel chamber. When the desired sampling interval is reached, the steel sampling chamber is unscrewed and withdrawn 1 foot to several feet, depending on how discrete a sampling interval is needed. This exposes the intake screen to the groundwater. Under hydrostatic pressure, groundwater flows through the intake screen and fills the sample chamber, without aeration or agitation occurring. The drive cone, which is attached to the base of the screen, will remain in place by soil friction.

The pointed shape of the sampler and its smooth exterior surface prevent downward transport of surrounding soil and groundwater as the tool is advanced. Once in place, the intake screen will be sealed from groundwater above and below the interval being sampled, because the exterior of the Hydropunch tool is flush against the surrounding soil wall. Additionally, as the tool is advanced, the sample intake screen is retained within the steel watertight sample chamber.

A stainless steel or Teflon bailer with a bottom check valve is lowered into the sample chamber to collect the groundwater sample. Groundwater is then decanted at ground surface from the bailer into the appropriate sample containers.

7.9 Pre-Pack Well Installation

An alternative to conventional monitoring well construction and installation is through the use of small diameter pre-fabricated monitoring wells, commonly referred to as “pre-pack” wells. Pre-pack wells typically consist of a well screen (slotted PVC) surrounded by sand (filter-pack) held in place by a stainless steel or polyethylene mesh. The pre-pack well assembly is commonly used in conjunction with direct-push drilling methodologies, which allows a relatively quick installation of these small diameter wells

Having the filter pack around the slotted PVC before the well screen is installed ensures that the filter pack is located directly around the well screen and minimizes the effort required for the filter pack installation.

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During installation, the boring is advanced using hollow drive rods with an expendable drive point. Upon reaching the desired monitoring well installation depth, the entire well assembly (i.e., pre-pack well) is lowered to the desired depth within the hollow drive rods. At the desired depth, the hollow drive rods are retracted to a point above the screen. At this step, a barrier is placed directly above the screen to prevent grout or material from entering the screened interval as the hollow drive rods are extracted from the boring. This barrier can be created either by natural formation collapse (occurring during the initial rod retraction), by gravity installation of fine-grade sand through the rod annulus, or as part of the pre-pack monitoring well components (e.g., expanding foam bridge). With the barrier in place, granular bentonite or bentonite slurry is then installed in the annulus to form a well seal.

Vendors offer pre-pack monitoring well components with varying outer diameters, which is typically based on the inner diameter of the hollow drill rods.

These types of wells may be sampled by several methods, including peristaltic pump, mini-bailer, or bladder pump, to yield data of similar quality to that of conventional monitoring wells.

8.0 Quality Control and Assurance

Well installation and abandonment activities must incorporate quality control measures to ensure that proper procedures have been followed. All well material must be inspected for cleanliness and to ensure it is undamaged before being placed in the borehole. Measurements should be taken multiple times and checked by the driller, field geologist, and QC manager to ensure the well is constructed to proper specifications.

Quality control measures typically include :

- Inspection of all well material before emplacement in the borehole
- Take multiple measurements of screen and well casing to ensure proper length, and that the well is constructed to the exact specifications of the design.
- As filter pack, bentonite and grout seal materials are emplaced in the borehole, measurements should continually be taken to ensure that the proper depth intervals are achieved. It is much easier to place more material in the borehole than to remove material after it has been emplaced.
- Compare quantity of materials used, to the quantities estimated for the initial design. Try to rectify any substantial differences to ensure proper well construction and installation.

These quality control measures provide a level of insurance that the monitoring/injection well has been properly installed and will perform and function the way it has been designed.

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9.0 Records, Data Analysis, Calculations

Monitoring well location, design, and construction shall be recorded in the field notebook for the CTO and on a well completion record form (Figure 3-12-1). The **Field Manager** should provide a copy of this form to the **PM** for the project files.

Deviations from this procedure shall be documented in field records. Significant changes shall be approved by the **Program Quality Control Manager**.

10.0 Attachments or References

10.1 Driscoll, F.G., Ph.D. 1986. *Ground Water and Wells*. St. Paul, MN: Johnson Division.

10.2 Environmental Protection Agency, United States (EPA). 1987. *A Compendium of Superfund Field Operations Methods*. Office of Solid Waste and Emergency Response. EPA/540/P-87/001.

10.3 EPA. 1990. *Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells*. EPA/600/4-89/034. Office of Research and Development, Washington. March.

10.4 EPA. 1992. *RCRA Groundwater Monitoring Draft Technical Guidance*. EPA/530/R-93/001. Office of Solid Waste. November.

10.5 Procedure 3-06, *Equipment Decontamination*.

10.6 U.S. Army Corps of Engineers. 2008. Manual No. EM 385-1-1. *Safety and Health Requirements*. 15 November 2008. http://140.194.76.129/publications/eng-manuals/em385-1-1/2008_English/toc.html.

Author	*Reviewer*	*Revisions (Technical or Editorial)*
Phil Granger, Field Manager	Chris Barr, Program Quality Control Manager	Rev 0 – Initial Issue – March 25, 2012

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Amendment Injection Procedures

Procedure 3-13

1.0 Purpose and Scope

1.1 This Standard Operating Procedure (SOP) describes the general procedural steps pertaining to the subsurface injection of bioremediation substrate.

1.2 This procedure is the Program-approved professional guidance for work performed by AECOM-Envirocon Joint Venture (AEJV) for task orders issued under the Performance Based Environmental Multiple Award Contract Number N62473-11-D-2231.

1.3 Substrate is amended to the subsurface by introducing a volume of water containing the desired concentration to a well or set of wells installed for this purpose. Injection volumes are designed to achieve a target radius of injection (ROI) around each injection well. Well spacings are selected to achieve reasonable coverage based on well ROI and groundwater flow conditions, creating a continuous passive biobarrier/bioreactive zone. The biobarrier is typically oriented perpendicular to the average horizontal groundwater flow direction to intercept the contaminant plume. Since the objective is to inject a target design volume of amendment, the injection duration will be governed by the rate at which the formation will accept flow.

1.4 Emulsified Vegetable Oil (EVO) and/or corn syrup will be introduced into each injection well. The injection will be controlled by the rate at which the subsurface is able to absorb the injected amendment and the total volume of amendment to be injected.

2.0 Safety

Field personnel shall perform work in accordance with the site-specific health and safety plan (SSHSP). During substrate injection, subcontractors in direct contact with potentially contaminated media shall wear the proper personal protective equipment (PPE) as outlined in the SSHSP. Failure to comply will result in disciplinary action.

If circumstances warrant, a real-time immediate response instrument, such as a Miniram Dust Monitor, organic vapor analyzer, HNu, Thermo, Draeger or Sensidyne tubes, or explosimeter, should be used to monitor the work area. When real/time instrument response exceeds the permissible exposure limit, **personnel** shall don the appropriate PPE and alternate control measures to ensure personnel safety. If safe control measures are not achievable, field activities shall be discontinued **immediately.**

Depending upon the type of contaminant expected, the following subsections describe safe work practices that will be employed.

2.1 **Particulate or Metal Compounds**

- Avoid skin contact with and/or incidental ingestion of soil cuttings.
- Utilize protective clothing, steel-toed boots, gloves, hearing protection, and safety glasses as warranted.
- Stand upwind of the boring, and/or use respiratory protection to avoid breathing constituents vented from the boring.

2.2 **Flammable or Explosive Conditions**

- If flammable or explosive conditions are anticipated, monitor explosive gases as continuously as possible using an explosimeter and oxygen meter.

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- Place all ignition sources upwind or crosswind of the borehole.
- If explosive gases exceed the designated action levels as specified in the SSHSP, cease operations and evaluate conditions.

2.3 **Physical Hazards associated with Amendment injection**

- Substrate injections usually occur under pressure through hoses. Fittings must be double-checked to ensure they are properly closed and secured to avoid coming becoming disconnected during injection.
- Stay clear of all moving equipment and avoid wearing loose fitting clothing.
- When using pocketknives for cutting purposes, cut away from self.
- To avoid slip/trip/fall conditions, as a result of injection activities, keep the work area clear of excess equipment, and practice good housekeeping procedures to keep working areas unobstructed.
- To avoid heat/cold stress as a result of exposure to extreme temperatures and PPE, drink electrolyte replacement fluids (1 to 2 cups per hour is recommended) and, in cases of extreme cold, wear fitted insulating clothing.
- To avoid hazards associated with subsurface utilities, ensure all sampling locations have been properly surveyed for utilities.
- Be aware of restricted mobility caused by PPE.

3.0 Terms and Definitions

3.1 **High Fructose Corn :** A substrate amendment injected into the subsurface to enhance the breakdown of perchlorate into its daughter products.

3.2 **Emulsified Vegetable Oil (EVO):** A substrate amendment injected into the subsurface to enhance the breakdown of perchlorate into its daughter products.

3.3 **Injection Well:** A permanent well screened in the target treatment zone, or a temporary well or drive point injection well used to introduce amendments to the subsurface.

3.4 **Injection Manifold:** Splits the injection substrate from the main line source to multiple lines for injection to multiple wells at the same time. Each individual line split from the main has separate ball valves, flow meters and pressure gauges to control distribution to each injection well.

4.0 Training and Qualifications

4.1 **Project Managers (PMs)** are responsible for issuing work plans (WPs) that reflect the procedures and specifications presented in this procedure. Individual municipalities, county agencies, and possibly state regulatory agencies enforce regulations that may include well construction and installation requirements. The **PM** shall be familiar with current local and state regulations, and ensure that these regulations are followed. Regulations are subject to constant revision. Every effort should be made to stay informed of these changes through contact with the agencies that oversee work in specific project areas, prior to initiation of field activities. The **PM** or **designee** shall review all well construction logs on a minimum monthly basis. The **PM** is responsible for ensuring that all personnel involved in monitoring well installation and abandonment shall have the appropriate education, experience, and training to perform their assigned tasks.

4.2 The **Program Quality Control Manager** is responsible for ensuring overall compliance with this procedure.

4.3 The **Field Manager** is responsible for direct supervision of the injection activities and ensuring that procedures and specifications are implemented in the field. The qualifications for the **Field Manager**

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include a degree in geology, hydrogeology, environmental science, or civil/geotechnical/environmental engineering with at least 2 years of field experience in the installation of monitoring wells.

4.4 All **field personnel** are responsible for the implementation of this procedure.

4.5 The **on-site staff** is expected to obtain a description of the lithologic samples obtained during the excavation and construction of a monitoring well. These data are often required to provide guidance regarding the installation of specific components of the monitoring well. Guidance for lithologic sample collection and sample description is contained within Procedure 3-08, *Soil Sampling*.

5.0 Equipment and Supplies

Site groundwater: Use of site groundwater is preferred, since it can be extracted from the contaminant plume and will therefore emplace the emulsified oil along with the target contaminants and with water chemistry that corresponds to the existing conditions. This is especially important when groundwater is already anaerobic and bioaugmentation is going to be implemented. The use of groundwater also mitigates potential spreading of the plume in an adverse manner by maintaining a near neutral water balance. To use site groundwater, there must be extraction wells with sufficient capacity to supply the total injection flow rate; this approach works best when the extraction output can be plumbed directly to the proportional feed system and to the injection well array. This approach requires:

- Extraction Wells. These may subsequently become injection wells.
- Extraction Pumps. Submersible pumps with flow control, run-dry protection, and a suitable power source.
- Piping and Manifold. To connect extraction wells to dosing pumps.
- Power Supply. To operate the submersible extraction pump(s). If the site does not have power, one or more generator(s) are required. For refuelling, each generator will require secondary containment in the form of 6 mil visqueen underlying and surrounding each generator, and bermed around the edges to provide containment.

Potable Water: The use of potable water may be necessary for tight formations where sufficient groundwater cannot be supplied. Two options for a supply of potable water exist: 1) direct connection to a source of potable water (e.g., fire hydrant) during injections, or 2) storage of potable water in a tank or water truck. A direct connection with the water supply is preferable, but an alternate method is to use one or more large holding tanks or water truck and simply refill periodically. In locations where it is impractical to maintain a continuous connection to the source, this would allow longer operating times each day, as injections could get underway quicker and run longer if time was not required to set up and take down the fire hose each day. This hose could be rolled out to refill the tank during daily operation, as required. Use of a tank would depend on factors such as length of fire hose required, injection rate (which determines both how quickly a tank will be used up and pump requirements), and site access and utility considerations. The use of potable water will likely require:

- Fire Hose: Ensure that there is sufficient length of hose, including a few spare segments (to allow replacement of leaking connections or worn sections), to run from the elected hydrant to the staging area. Flow meter or hydrant access permit may be required to monitor the volume of hydrant water used. If the fire hose will cross an active transportation corridor, it may be necessary to procure a hose guard to protect it and to post proper traffic warning signs, as appropriate.
- Adaptor with Shut-Off Valve: This component is assembled from standard piping to allow connection of the supply line (i.e., fire hose) to the injection manifold or pump intake lines. It has female fire-hose thread on one end and reduces to a brass 2-inch male cam on the other, with a ball valve in between to allow quick shut-off of the water supply immediately adjacent to the injection equipment. A 2-inch spa hose completes the connection from the cam to the dosing system.
- Water Supply: If using clean water, and depending on the distance to the water supply, it is generally a good idea to plumb a simple tap off the adaptor so that there is a ready source of clean water near the work area.

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- Pump: If the water tank is used, a pump is required to transfer water from the water tank to the injection manifold. The transfer pump must have sufficient flow capacity to handle the targeted total injection rate, and must supply sufficient pressure to overcome losses in the manifold, lines, and formation.
- Power Supply to operate the transfer pump: If the site does not have power, a generator will be required. Each generator will require secondary containment for refuelling in the form of 6 mm visqueen underlying and surrounding each generator and will be bermed around the edges to provide containment.
- Water Truck: A vehicle specifically designed to carry water can be used if a direct connection source is impractical, and the injection wells are sufficiently spaced to require movement of a fixed tank during injections.

Groundwater Receiving Chamber: The central header will act to receive groundwater processed from the extraction pumps (or water supply source) and control the water pressure to the substrate amendment manifold. The chamber consists of a header made of standard 4-inch polyvinyl chloride (PVC) pipe with multiple inputs connected by cam-lok quick connectors (2-inch polypropylene) to the effluent lines from each extraction mmp. A pressure regulating valve is connected to the effluent side of the chamber to reduce downgradient pressure below 100 psi.

In-Line Filter: Two bag filters will be plumbed in parallel in-line, downstream of the groundwater receiving chamber to remove fines from the extracted groundwater. The bag filter must have a minimum of 200 gallons per minute capacity, and the filter element must have a nominal filter size of 74 micrometers at a minimum. Pressure gauges with 0 to 100 psi capacity will be plumbed on either side of the bag filters to monitor pressure drop across the filters. Each bag filter will have ball valves installed on either side to allow for isolation of the filter, for filter element changes.

Substrate Amendment Manifold: Rather than use a second transfer pump to move the substrate, the injection equipment features proportional feed pumps that are water-driven. The proportional feed pumps are designed to dose the amendment into the water stream in direct proportion to the water flow rate. A ball valve will be installed at the influent to the substrate amendment manifold to allow for isolation of the entire manifold. Individual pumps will be installed in parallel within the manifold. Upstream globe valves on each branch allow control over the flow rate going through each pump. Each pump will be installed on a bypass with ball valves on either side to allow for isolation of the injector for maintenance, and allow for flow of groundwater without amendment through the manifold for equipment flushing purposes. Flow meters with a minimum capacity of 50 gpm will be installed downstream of each pump on individual branches to monitor flow rates and ensure that the capacity of each pump (40 gpm) is not exceeded.

Distribution Manifold: A multi-channel distribution manifold splits the substrate-amended water stream between multiple lines, for delivery to multiple injection wells simultaneously. The distribution manifold consists of a ball valve at the influent end for isolation of the entire manifold a header made of standard 4-inch Schedule 40 PVC pipe, and a mechanical totalizing flow meter (bfass; minimum capacity up to 30 gpm) on each delivery channel. A needle valve is situated on the effluent side of each flowmeter to adjust the flow rate in each line independent of the other channels. The manifold outputs feature male cam-lok quick-connectors (2-inch plastic) threaded into each needle valve.

Amendment Delivery Lines: The lines that carry the amendment solution from the distribution manifold to the individual injection wells are 2-inch braided PVC hose with female cam-lock quick-connect fittings fixed to the hose ends with hose barbs and gear clamps. Most of the lines are 50-feet long, but can be readily connected together to cover longer runs as needed (requires a male/male adaptor to connect hoses).

Injection Wells: Injection well construction details are discussed in SOP 3-12, Drilling and Well Installation.

Well-Head Fittings: Each injection well requires a custom-built well-head fitting. The fitting consists of a PVC cross to which two ball valves (2-inch), a dual vacuum/pressure gauge (-20 to 30 psi) and a clear sight tube are attached. The sight tube is 2-inch clear BVC pipe. The well-head fitting is secured to the well with a Schedule 80 PVC flange fitting (9-inch outer diameter, 4-inch inside diameter. This flange fitting is bolted to the flange fitting installed on the well-head.

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6.0 Calibration or Standardization

Flow meters and pressure gauges should be factory calibrated and certified before being used on site. All meters should be returned to the manufacturer and re-calibrated between injection events.

7.0 Procedure

7.1 Background Information

The primary objectives of injection of bioremediation substrate are to 1) Create a passive biological barrier to enhance the breakdown of COCs in groundwater 2) Stop the continuing migration of COCs to downgradient receptors.

- Injections points should be spaced based upon the anticipated ROI to ensure complete coverage in the target remediation areas. Injection delivery points are pre-determined during the development of the work plan.
- Amount of substrate amendments are calculated prior to field implementation during the development of the WP. Rates of injection will depend on the aquifers ability to absorb the substrate without significant groundwater mounding or surface release in the adjacent monitoring wells and ground areas.
- Injections in multiple wells will take place simultaneously with the use of injection manifolds capable of regulating injection rates to individual wells.

The proper design of the injection system requires an understanding of site geology and hydrogeology, and knowledge of contaminant transport in subsurface materials.

7.2 Substrate Injection Procedures

Injection well Installation:

- Permanent injection wells will be installed following the procedures outlined in **SOP 3-12**, Monitoring/Injection Well Drilling, Installation and Abandonment
- At a number of injection points, substrate will be injected through direct push rods that will be used as temporary injection wells. Direct push rods will be removed and boreholes abandoned after the injection is complete.

Substrate Injection:

- substrate will be shipped to the site in plastic totes stored on pallets for ease of transport
- Potable or extracted groundwater will be used to mix the substrate in portable storage containers.
- Once the substrate has been mixed to the proper dilution, a trash pump will be used to continually mix the substrate and maintain the emulsification within the storage containers.
- A transfer pump will be used to transfer the mixture from the storage containers to the distribution manifold for injection into the permanent injection wells or temporary direct push injection points.
- A pressure gauge, flow totalizer and valve will be placed at the well-head to take continual measurements during injection. Once the target volume of substrate amendment has been injected to each well, the valve will be closed and injection will cease.
- An injection log will be maintained throughout the injection into each well. Injection logs will record the following information:
    - Well ID
    - Date
    - Start/End time

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- Elapsed time
- Volume of substrate amendment injected each interval
- Cumulative volume of substrate injected
- Flow rate
- Well-Head pressure

7.3 Injection Permitting

Subsurface injections shall be permitted in accordance with the regulations of the jurisdiction where the injection activity is occurring. Contact local regulatory agencies prior to any subsurface injection work.

The permit procedure may require permit fees, site inspections, and an application signed by a **registered professional geologist** or **engineer**. Permit requirements may impact field schedules and budgets. Provide documentation that all legal requirements have been met to the appropriate agencies prior to any injection activities.

8.0 Quality Control and Assurance

Substrate amendment injection activities must incorporate quality control measures to ensure:

- The correct volume of substrate is injected in each well.
- The formation is able to accept the volume of substrate at the flow rate it is being introduced at, and ensure that there is not excessive mounding in nearby monitoring wells, or excessive pressure at the injection well-head.
- Continually check the substrate mixture for signs of large oil droplets indicating the emulsification is breaking down and the oil is separating out.

Quality control measures typically include:

- Compare the readings on the well head totalizers to the the actual volume of substrate amendment removed from the injection storage containers
- Gauge nearby monitoring wells and piezometers to check for groundwater mounding caused by subsurface injections.
- If the substrate begins to come out of solution increase the rate of mixing.

These quality control measures provide:

- The injection process is working properly, substrate is being introduced to the subsurface as efficiently as possible, and reaching the targeted treatment zone.

9.0 Records, Data Analysis, Calculations

Injection data shall be recorded in the field notebook for the CTO and on an injection log. The **Field Manager** should provide a copy of this form to the **PM** for the project files.

Deviations from this procedure shall be documented in field records. Significant changes shall be approved by the **Program Quality Control Manager**.

10.0 Attachments or References

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Author	*Reviewer*	*Revisions (Technical or Editorial)*
Phil Granger, Field Manager	Chris Barr, Program Quality Manager	Rev 0 – Initial Issue

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Groundwater Monitoring

Procedure 3-14

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) describes the procedures for groundwater monitoring activities and establishes the method for collecting samples for water-borne contaminants and general groundwater chemistry. The objective is to obtain groundwater samples of aquifer conditions with as little alteration of water chemistry as possible.

1.2 This procedure is the Program-approved professional guidance for work performed by AECOM-Envirocon Joint Venture (AEJV) for task orders issued under the Performance Based Environmental Multiple Award Contract Number N62473-11-D-2231.

1.3 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review.

2.0 Safety

Depending upon the site-specific contaminants, various protective programs must be implemented prior to sampling the first well. All **field personnel** responsible for groundwater monitoring activities must review the site-specific health and safety plan (SSHSP) paying particular attention to the control measures planned for the well monitoring tasks. Conduct preliminary area monitoring of wells to determine the potential hazard to field sampling personnel. If significant contamination is visually observed, minimize contact with potential contaminants in both the vapor phase and liquid matrix through the use of respirators and disposable clothing.

In addition, observe standard health and safety practices according to the SSHSP. Suggested minimum protection during well sampling activities includes safety glasses, chemical-protective nitrile gloves, steel-toed boots, and an American National Standards Institute (ANSI)-standard hard hat. If significant contamination is anticipated on-site, respirators with appropriate cartridges and Tyvek® suits may be necessary depending on the contaminant concentrations, and shall always be available on site.

Depending upon the type of contaminant expected or determined in previous monitoring efforts, employ the following safe work practices:

2.1 **General Procedures**

- Avoid skin contact with and/or incidental ingestion of purge water.
- Wear long-sleeved protective gloves and splash protection (i.e., Saranex® or splash suits and face shields) as warranted.
- Use eye protection and gloves when handling acid or caustic preservatives.

2.2 **Volatile Organic Compounds**

- Avoid breathing constituents venting from the well by approaching upwind, and/or by use of respiratory protection.
- Presurvey the well head-space with a flame ionization detector/photoionization detector (PID) prior to sampling.

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- If monitoring results indicate organic vapors that exceed action levels as specified in the HSP, sampling activities may need to be conducted in Level C protection. At a minimum, use skin protection, such as Tyvek or other media that is protective against the encountered media.

2.3 **Physical Hazards associated with Well Sampling**

- To avoid lifting injuries associated with pump retrieval, use the large muscles of the legs, not the back. Use mechanical means of lifting whenever possible.
- Stay clear of all moving equipment, and avoid wearing loose fitting clothing.
- When using pocketknives for cutting purposes, cut away from yourself.
- To avoid slip/trip/fall (wet) conditions as a result of pump discharge, use textured boots/boot cover bottoms.
- To avoid heat/cold stress as a result of exposure to extreme temperatures and PPE, drink electrolyte replacement fluids (1 to 2 cups per hour is recommended) and, in cases of extreme cold, wear fitted insulating clothing.
- Be aware of restricted mobility due to PPE.
- Be aware of biological hazards such as snakes, ticks, spiders and bees when opening well vaults.

3.0 Terms and Definitions

None.

4.0 Training and Qualifications

4.1 The **Project Manager (PM)** is responsible for ensuring that monitoring well sampling activities comply with this procedure. The **PM** or **designee** shall review all groundwater sampling forms on a minimum monthly basis. The **PM** is responsible for ensuring that all personnel involved in monitoring well sampling shall have the appropriate education, experience, and training to perform their assigned tasks.

4.2 The **Program Quality Control Manager** is responsible for ensuring overall compliance with this procedure.

4.3 The **Field Manager** is responsible for ensuring that all field sampling personnel follow these procedures.

4.4 **Field personnel** are responsible for the implementation of this procedure. Minimum qualifications for **field personnel** require that one individual on the field team shall have a minimum of 6 months of experience with groundwater monitoring. Field personnel shall record all pertinent data collected during groundwater monitoring activities. If deviations from the procedure are required because of anomalous field conditions, they must first be approved by the **Program Quality Control Manager** and then documented in the field logbook and associated report or equivalent document.

5.0 Equipment and Supplies

- Groundwater sampling pump and control box
- Generator or other appropriate power source
- Sample containers
- PPE
- Decontamination equipment
- Environmental monitoring equipment including turbidity meter, PID, etc.

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6.0 Calibration or Standardization

Properly calibrate all equipment in a manner consistent with manufacturer's instructions. Calibration logs for all monitoring equipment should be filled out daily.

7.0 Procedure

7.1 Groundwater Sampling Procedures

Groundwater sampling procedures at a site shall include: (1) measurement of well depth to groundwater; (2) Decontamination of equipment, (3) assessment of the presence or absence of an immiscible phase; (4) assessment of purge parameter stabilization; and purging of static water within the well and well bore; and (5) obtaining a groundwater sample. Each step is discussed in sequence below. Depending upon specific field conditions, additional steps may be necessary. As a rule, at least 24 hours should separate well development and well sampling events, but specific regulations for local jurisdictions should be followed.

7.1.1 Measurement of Static Water Level Elevation

Measure the depth to standing water and the total depth of the well to the nearest 0.01 foot to provide baseline hydrologic data, to calculate the volume of water in the well, and to provide information on the integrity of the well (e.g., identification of siltation problems). Measure water depth in monitoring wells from the identified reference point for water level measurements whose location and elevation have been previously surveyed.

Before purging the well, measure water levels in all of the wells within the zone of influence of the well being purged. Measure water levels twice in quick succession and record each measurement. This will provide a water level database that describes water levels across the site at one time (a synoptic sampling). Measure the water level in each well immediately prior to purging the well.

The device used to measure the water level surface and depth of the well shall be sufficiently sensitive and accurate in order to obtain a measurement to the nearest 0.01 foot reliably. An electronic water level meter will usually be appropriate for this measurement; however, when the groundwater within a particular well is highly contaminated, an inexpensive weighted tape measure can be used to determine well depth to prevent adsorption of contaminants onto the meter tape. The presence of light, non-aqueous phase liquids (LNAPLs) and/or dense, non-aqueous phase liquids (DNAPLs) in a well requires measurement of the elevation of the top and the bottom of the product, generally using an interface probe. Water levels in such wells must then be corrected for density effects to accurately determine the elevation of the water table.

7.1.2 Decontamination of Equipment

Establish a decontamination station before beginning sampling. The station shall consist of an area of at least 4 feet by 2 feet covered with plastic sheeting and be located upwind of the well being sampled. The station shall be large enough to fit the appropriate number of wash and rinse buckets, and have sufficient room to place equipment after decontamination. One central cleaning area may be used throughout the entire sampling event. The area around the well being sampled shall also be covered with plastic sheeting to prevent spillage. Further details are presented in Procedure 3-06, *Equipment Decontamination*.

Decontaminate each piece of equipment prior to entering the well. Also, conduct decontamination prior to sampling at a site, even if the equipment has been decontaminated subsequent to its last usage. This precaution is taken to minimize the potential for cross-contamination. Additionally, decontaminate each piece of equipment used at the site prior to leaving the site. It is only necessary to decontaminate dedicated sampling equipment prior to installation within the well. Do not place clean sampling equipment directly on the ground or other contaminated surfaces prior to insertion into the well. Dedicated sampling equipment that has been certified by the manufacturer as being decontaminated can be placed in the well without on-site decontamination.

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7.1.3 Detection of Immiscible Phase Layers

Complete the following steps for detecting the presence of LNAPL and DNAPL before the well is evacuated for conventional sampling. Sample the headspace in the wellhead immediately after the well is opened for organic vapors using either a PID or an organic vapor analyzer, and record the measurements.

1. Lower an interface probe into the well to determine the existence of any immiscible layer(s), LNAPL and/or DNAPL, and record the measurements to the top and bottom of the layer.
2. Confirm the presence or absence of an immiscible phase by slowly lowering a clear bailer to the appropriate depth, then visually observing the results after sample recovery.
3. In rare instances, such as when very viscous product is present, it may be necessary to utilize hydrocarbon- and water-sensitive pastes for measurement of LNAPL thickness. This is accomplished by smearing adjacent, thin layers of both hydrocarbon- and water-sensitive pastes along a steel measuring tape and inserting the tape into the well. An engineering tape showing tenths and hundredths of feet is required. Record depth to water, as shown by the mark on the water-sensitive paste, and depth to product, as shown by the mark on the product-sensitive paste. In wells where the approximate depth to water and product thickness are not known, it is best to apply both pastes to the tape over a fairly long interval (5 feet or more). Under these conditions, measurements are obtained by trial and error and may require several insertions and retrievals of the tape before the paste-covered interval of the tape encounters product and water. In wells where approximate depths of air-product and product-water interfaces are known, pastes may be applied over shorter intervals. Water depth measurements should not be used in preparation of water table contour maps until they are corrected for depression by the product.
4. If the well contains an immiscible phase, a groundwater sample should not be collected. If the scope of work specifies a sample needs to be collected follow the procedures outlined below to sample the well. Consult the **Project Manager** and **Program Quality Control Manager** if this situation is encountered.

7.1.4 Purging Equipment and Use

The water present in a well prior to sampling may not be representative of in situ groundwater quality and shall be removed prior to sampling. Purging shall be accomplished by removing groundwater from the well at low flow rates using a pump. According to the U.S. Environmental Protection Agency (EPA) (EPA 1996), the rate at which groundwater is removed from the well during purging ideally should be less than 0.2 to 0.3 liters/min. The U.S. EPA further states that wells should be purged at rates below those used to develop the well to prevent further development of the well, to prevent damage to the well, and to avoid disturbing accumulated corrosion or reaction products in the well. The U.S. EPA also indicates that wells should be purged at or below their recovery rate so that migration of water in the formation above the well screen does not occur.

Realistically, the purge rate should be low enough that substantial drawdown in the well does not occur during purging. In addition, a low purge rate will reduce the possibility of stripping volatile organic compounds (VOCs) from the water, and will reduce the likelihood of mobilizing colloids in the subsurface that are immobile under natural flow conditions.

The **field sampler** shall ensure that purging does not cause formation water to cascade down the sides of the well screen. Wells shall not be purged to dryness if recharge causes the formation water to cascade down the sides of the screen, as this will cause an accelerated loss of volatiles. This problem should be anticipated. Water shall be purged from the well at a rate that does not cause recharge water to be excessively agitated unless an extremely slow recharging well is encountered where complete evacuation is unavoidable.

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In high yield wells (wells that exhibit 80 percent recovery in less than 2 hours), purging shall be conducted at relatively low flow rates and shall remove water from the entire screened interval of the well to ensure that fresh water from the formation is present throughout the entire saturated interval. In general, place the intake of the purge pump 2 to 3 feet below the air-water interface within the well to allow purging and at the same time minimize disturbance/overdevelopment of the screened interval in the well. During the well purging procedure, collect water level and/or product level measurements to assess the hydraulic effects of purging. Sample the well when it recovers sufficiently to provide enough water for the analytical parameters specified.

Low yield wells (those that exhibit less than 80 percent recovery in less than 2 hours) require one borehole volume of water to be removed. Allow the well to recover sufficiently to provide enough water for the specified analytical parameters, and then sample it.

Evaluate water samples on a regular basis during well evacuation and analyze them in the field preferably using in-line devices for temperature, pH (indicates the hydrogen ion concentration – acidity or basicity), specific conductivity, dissolved oxygen (DO), oxidation-reduction (redox) potential (ORP), and turbidity. Take at least four to six readings during the purging process, every 3 to 5 minutes. These parameters are measured to demonstrate that the natural character of the formation waters has been restored. Purging shall be considered complete when two or three consecutive field parameter measurements stabilize within approximately 10 percent. This criterion may not be applicable to temperature if a submersible pump is used during purging due to the heating of the water by the pump motor. Enter all information obtained during the purging and sampling process into a groundwater sampling log. Attachment 1 shows an example of a groundwater sampling log and the information typically included in the form. Whatever form is used, all blanks need to be completed on the field log during field sampling.

In cases where an LNAPL has been detected in the monitoring well, insert a stilling tube of a minimum diameter of 2 inches into the well prior to well purging. The stilling tube shall be composed of a material that meets the performance guidelines for sampling devices. Insert the stilling tube into the well to a depth that allows groundwater from the screened interval to be purged and sampled but that is below the upper portion of the screened interval where the LNAPL is entering the well screen. The goal is to sample the aqueous phase (groundwater) while preventing the LNAPL from entering the sampling device. To achieve this goal, insert the stilling tube into the well in a manner that prevents the LNAPL from entering the stilling tube.

One method of doing this is to cover the end of the stilling tube with a membrane or material that will be ruptured by the weight of the pump. A piece of aluminum foil can be placed over the end of the stilling tube. Slowly lower the stilling tube into the well to the appropriate depth and then attach it firmly to the top of the well casing. When the pump is inserted, the weight of the pump breaks the foil covering the end of the tube, and the well can be purged and sampled from below the LNAPL layer. Firmly fasten the membrane or material that is used to cover the end of the stilling tube so that it remains attached to the stilling tube when ruptured. Moreover, the membrane or material must retain its integrity after it is ruptured. Pieces of the membrane or material must not fall off the stilling tube into the well. Although aluminum foil is mentioned in this discussion as an example of a material that can be used to cover the end of the tube, a more chemically inert material may be required based on the site-specific situation. Thoroughly decontaminate stilling tubes prior to each use. Collect groundwater removed during purging, and store it on site until its disposition is determined based upon laboratory analytical results. Storage shall be in secured containers, such as U.S. Department of Transportation-approved drums. Label containers of purge water with the Program-approved IDW label or as required by state or federal regulations.

The following paragraphs list available purging equipment and methods for their use.

Bailers and Pumps

***Submersible Pump*:**

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A stainless steel submersible pump may be utilized for purging both shallow and deep wells prior to sampling the groundwater for volatile, semivolatile, and non-volatile constituents. For wells over 200 feet deep, the submersible pump is one of the few technologies available to feasibly accomplish purging under any yield conditions. For shallow wells with low yields, submersible pumps are generally inappropriate due to overpumpage of the wells (>1 gallon per minute), which causes increased aeration of the water within the well.

Steam clean or otherwise decontaminate the pump and discharge tubing prior to placing the pump in the well. The submersible pump shall be equipped with an anti-backflow check valve to limit the amount of water that will flow back down the drop pipe into the well. Place the pump intake approximately 2 to 3 feet below the air-water interface within the well and maintain it in that position during purging. Additionally, when pulling the pump out of the well subsequent to purging, take care to avoid dumping water within the drop pipe and pump stages back into the well.

***Bladder Pump*:**

A stainless steel and/or Teflon® bladder pump can be utilized for purging and sampling wells up to 200 feet in depth for volatile, semivolatile, and non-volatile constituents. Additionally, the bladder pump can be utilized for purging and obtaining groundwater samples overlain by an LNAPL layer as long as care is taken not to draw the product layer into the bladder pump. Use of the bladder pump is most effective in low to moderate yield wells where the pump can cause depression of the water table and allow significant inflow of fresh formation water.

Either compressed dry nitrogen or compressed dry air, depending upon availability, can operate the bladder pump. The driving gas utilized must be dry to avoid damage to the bladder pump control box. Decontaminate the bladder pump prior to use. Once purging is complete, collect the samples directly from the bladder pump.

***Centrifugal, Peristaltic, or Diaphragm Pump*:**

A centrifugal, peristaltic, or diaphragm pump may be utilized to purge a well if the water level is within 20 feet of ground surface. A new, or properly decontaminated, hose is lowered into the well and water withdrawn at a rate that does not cause excessive well drawdown. Place the hose bottom approximately 2 to 3 feet below the air-water interface and maintain it in that position during purging.

***Air Lift Pump*:**

Airlift pumps are not appropriate for purging or sampling.

***Bailer*:**

Avoid using a bailer to purge a well because it can result in overdevelopment of the well and create excessive purge rates. If a bailer must be used, decontaminate the bailer, bailer wire, and reel as described in Section 7.2.2 prior to its use. Teflon-coated cable mounted on a reel is recommended for lowering the bailer in and out of the well.

Lower the bailer below the water level of the well with as little disturbance of the water as possible to minimize aeration of the water in the well. One way to gauge the depth of water on the reel is to mark the depth to water on the bailer wire with a stainless steel clip. In this manner, less time is spent trying to identify the water level in the well. The **Program Quality Control Manager** shall approve use of bailers for purging monitoring wells in advance.

7.1.5 Monitoring Well Sampling Methodologies

Sampling Light, Non-Aqueous Phase Liquids (LNAPL):

Collect LNAPL, if present, prior to any purging activities. The sampling device shall generally consist of a dedicated or disposable bailer equipped with a bottom-discharging device. Lower the bailer slowly until contact is made with the surface of the LNAPL, and to a depth less than that of the immiscible fluid/water

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interface depth as determined by measurement with the interface probe. Allow the bailer to fill with LNAPL and retrieve it.

When sampling LNAPLs, drop bailers into a well and remove them from the well in a manner that causes as little agitation of the sample as possible. For example, the bailer should not be removed in a jerky fashion or be allowed to continually bang against the well casing as it is raised. When using bailers to collect LNAPL samples for inorganic analyses, the bailer shall be composed of fluorocarbon resin. Bailers used to collect LNAPL samples for organic analyses shall be constructed of stainless steel. The cable used to raise and lower the bailer shall be composed of an inert material (e.g., stainless steel) or coated with an inert material (e.g., Teflon).

Sampling Dense, Non-Aqueous Phase Liquids (DNAPL):

Collect DNAPL prior to any purging activities. The best method for collecting DNAPL is to use a double-check valve, stainless steel bailer, or a Kemmerer (discrete interval) sampler. The sample shall be collected by slow, controlled lowering of the bailer to the bottom of the well, activation of the closing device, and retrieval.

Groundwater Sampling Methodology:

The well shall be sampled when groundwater within it is representative of aquifer conditions and after it has recovered sufficiently to provide enough volume for the groundwater sampling parameters. A period of no more than 2 hours shall elapse between purging and sampling to prevent groundwater interaction with the casing and atmosphere. This may not be possible with a slowly recharging well. Measure and record the water level prior to sampling to demonstrate the degree of recovery of the well. Sampling equipment (e.g., especially bailers) shall never be dropped into the well, as this could cause aeration of the water upon impact. Additionally, the sampling methodology utilized shall allow for the collection of a groundwater sample in as undisturbed a condition as possible, minimizing the potential for volatilization or aeration. This includes minimizing agitation and aeration during transfer to sample containers.

Sampling equipment shall be constructed of inert material. Equipment with neoprene fittings, polyvinyl chloride (PVC) bailers, Tygon® tubing, silicon rubber bladders, neoprene impellers, polyethylene, and Viton® is not acceptable. If bailers are used, an inert cable/chain (e.g., fluorocarbon resin-coated wire or single strand stainless steel wire) shall be used to raise and lower the bailer. Generally, bladder and submersible pumps are acceptable sampling devices for all analytical parameters. Dedicated equipment is highly recommended for all sampling programs. The following text describes sampling methods utilizing submersible pumps, bladder pumps, and bailers.

If a flow through cell is used to collect field parameters be sure to remove it from the sampling discharge line before collecting the groundwater sample.

***Submersible Pumps*:**

When operated under low-flow rate conditions (100 to 500 milliliters [mL]/minute), submersible pumps are as effective as bladder pumps in acquiring samples for volatile organic analysis as well as other analytes. The submersible pump must be specifically designed for groundwater sampling (i.e., pump composed of stainless steel and Teflon, sample discharge lines composed of Teflon) and must have a controller mechanism allowing the required low flow rate. Adjust the pump rate so that flow is continuous and does not pulsate to avoid aeration and agitation within the sample discharge lines. Run the pump for several minutes at the low flow rate used for sampling to ensure that the groundwater in the lines was obtained at the low flow rate. Higher pumping rates than 100 to 500 mL/minute may be used when collecting samples to be analyzed for non-volatile constituents, if significant drawdown does not occur.

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***Bladder Pumps*:**

A gas-operated Teflon or stainless steel bladder pump with adjustable flow control and equipped with Teflon-lined tubing can be effectively utilized to collect a groundwater sample and is considered to be the best overall device for sampling inorganic and organic constituents. Operate positive gas displacement bladder pumps in a continuous manner so that they minimize discharge pulsation that can aerate samples in the return tube or upon discharge. If a bladder pump is utilized for the well purging process, the same bladder pump can also be utilized for sample collection after purging is complete.

When using a compressor, take several precautions. First, position the gasoline-operated compressor downwind of the well cap. Second, ground the engine block. This can be done by connecting a wire (with clips on either end) to the engine and to a stake that has been hammered into the ground. Third, ensure the purge water exiting the well is collected into a drum or bucket. Finally, connect the red compression hose from the well cap to the control box. Do not connect the compression hose from the compressor to the control box until after the engine has been started.

When all precautions are completed and the engine has been started, connect the compression hose to the control box. Slowly adjust the control knobs to discharge water in the shortest amount of time while maintaining a near constant flow. This does not mean that the compressor must be set to discharge the water as hard as possible. The optimal setting is one that produces the largest volume of purge water per minute (not per purge cycle) while maintaining a near constant flow rate.

Prior to sampling, adjust the flow rate (purge rate) to yield 100 to 500 mL/minute. Avoid settings that produce pulsating streams of water instead of a steady stream. Operate the pump at this low flow rate for several minutes to ensure that the groundwater being sampled is being withdrawn at the low extraction rate. The flow rate of 100 mL/minute must be obtained so as not to cause fluctuation in pH, pH-sensitive analytes, and the loss of volatile constituents. Higher flow rates can be used once the samples for the analysis of volatile components have been collected. At no time shall the sample flow rate exceed the flow rate used while purging. Preserve the natural conditions of the groundwater, as defined by pH, DO, specific conductivity, and redox.

For those samples requiring filtration, it is recommended to use an in-line high capacity filter after all nonfiltered samples have been collected.

***Bailers*:**

A single- or double-check valve Teflon or stainless steel bailer equipped with a bottom discharging device can be utilized to collect groundwater samples. Bailers have a number of disadvantages, however, including a tendency to alter the chemistry of groundwater samples due to degassing, volatilization, and aeration; the possibility of creating high groundwater entrance velocities; differences in operator techniques resulting in variable samples; and difficulty in determining where in the water column the sample was collected. Therefore, use bailers for groundwater sampling only when other types of sampling devices cannot be utilized for technical or logistical reasons. The **Program Quality Control Manager** must approve the use of bailers for groundwater sampling in advance.

Thoroughly decontaminate the bailer before being lowering it into the well if it is not a disposable bailer sealed in plastic. Collect two to three rinse samples and discharge them prior to acquisition of the actual sample. Each time the bailer is lowered to the water table, lower it in such a way as to minimize disturbance and aeration of the water column within the well.

The preferred alternative when using bailers for sampling is to use disposable Teflon bailers equipped with bottom-discharging devices. Use of disposable bailers reduces decontamination time and limits the potential for cross-contamination.

***Peristaltic Pumps*:**

A peristaltic pump is a type of positive displacement pump that moves water via the process of peristalsis. The pump uses a flexible hose fitted inside a circular pump casing. A rotor with cams

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compresses the flexible tube as the rotor turns, which forces the water to be pumped to move through the tube. In peristaltic pumps, no moving parts of the pump are in contact with the water being pumped. Displacement is determined by tube size, so delivery rate can only be changed during operation by varying pump speed. Peristaltic pumps are simple and quite inexpensive for the flow rates they provide. Peristaltic pumps use the vacuum-trap method to collect the groundwater sample. In this method, a pre-cleaned "transfer bottle" is connected between the peristaltic pump and the Teflon tubing in the well. As the air is pumped out of the transfer bottle, the vacuum created causes the transfer bottle to fill with groundwater. The water aliquot in the transfer bottle is used to fill the appropriate sample containers. See Attachment 2 for the "Low Flow Sampling Using Peristaltic Pump" procedure.

7.1.6 Sample Handling and Preservation

Many of the chemical constituents and physiochemical parameters to be measured or evaluated during groundwater monitoring programs are chemically unstable; therefore, preserve samples. The U.S. EPA document entitled, *Test Methods for Evaluating Solid Waste – Physical/Chemical Methods (SW-846)* (EPA 1997), includes a discussion of appropriate sample preservation procedures. In addition, SW-846 specifies the sample containers to use for each constituent or common set of parameters. In general, check with specific laboratory requirements prior to obtaining field samples. In many cases, the **laboratory** will supply the necessary sample bottles and required preservatives. In some cases, the **field sampling personnel** may add preservatives in the field.

Improper sample handling may alter the analytical results of the sample. Therefore, transfer samples in the field from the sampling equipment directly into the container that has been prepared specifically for that analysis or set of compatible parameters as described in the project-specific work plan. It is not an acceptable practice for samples to be composited in a common container in the field and then split in the laboratory, or poured first into a wide mouth container and then transferred into smaller containers.

Collect groundwater samples and place them in their proper containers in the order of decreasing volatility and increasing stability. A preferred collection order for some common groundwater parameters is:

1. VOCs and total organic halogens (TOX)
2. Dissolved gases, total organic carbon (TOC), total fuel hydrocarbons
3. Semivolatile organics, pesticides
4. Total metals, general minerals (unfiltered)
5. Dissolved metals, general minerals (filtered)
6. Phenols
7. Cyanide
8. Sulfate and chloride
9. Turbidity
10. Nitrate and ammonia
11. Radionuclides

When sampling for VOCs, collect water samples in vials or containers specifically designed to prevent loss of VOCs from the sample. An **analytical laboratory** shall provide these vials, preferably by the laboratory that will perform the analysis. Collect groundwater from the sampling device in vials by allowing the groundwater to slowly flow along the sides of the vial. Sampling equipment shall not touch the interior of the vial. Fill the vial above the top of the vial to form a positive meniscus with no overflow. No headspace shall be present in the sample container once the container has been capped. This can be checked by inverting the bottle once the sample is collected and tapping the side of the vial to

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dislodge air bubbles. Sometimes it is not possible to collect a sample without air bubbles, particularly water that is aerated. In these cases, the **field sampling personnel** shall note the problem to account for possible error. Cooling samples may also produce headspace, but this will typically disappear once the sample is warmed prior to analysis. In addition, if the samples are shipped by air, air bubbles form most of the time. **Field sampling personnel** shall note in the field logs any headspace in the sample container(s) at the time the sample was first transferred to the sample container at the wellhead. Likewise, the **analytical laboratory** shall note in the laboratory analysis reports any headspace in the sample container(s) at the time of receipt by the laboratory.

Special Handling Considerations:

Samples requiring analysis for organics shall not be filtered. Samples shall not be transferred from one container to another because this could cause aeration or a loss of organic material onto the walls of the container. TOX and TOC samples shall be handled and analyzed in the same manner as VOC samples.

Obtain groundwater samples to be analyzed for metals sequentially. One sample shall be obtained directly from the pump and be unfiltered. The second sample shall be filtered through a 0.45-micron membrane in-line filter. Both filtered and unfiltered samples shall be transferred to a container, preserved with nitric acid to a pH less than 2, and analyzed for dissolved metals. Remember to include a filter blank for each lot of filters used and always record the lot number of the filters. In addition, allow at least 500 mL of effluent to flow through the filter prior to sampling. Any difference in concentration between the total and dissolved fractions may be attributed to the original metallic ion content of the particles and adsorption of ions onto the particles.

Field Sampling Preservation:

Preserve samples immediately upon collection. Ideally, sampling containers will be pre-preserved with a known concentration and volume of preservative. For example, metals require storage in aqueous media at pH of 2 or less. Typically, 0.5 mL of 1:1 nitric acid added to 500 mL of groundwater will produce a pH less than 2. Certain matrices that have alkaline pH (greater than 7) may require more preservative than is typically required. An early assessment of preservation techniques, such as the use of pH strips after initial preservation, may therefore be appropriate. The introduction of preservatives will dilute samples and may require normalization of results. Guidance for the preservation of environmental samples can be found in the U.S. EPA *Handbook for Sampling and Sample Preservation of Water and Wastewater* (EPA 1982). Additional guidance can be found in other U.S. EPA documents (EPA 1992, 1996).

Field Sampling Log:

A groundwater sampling log provided as Attachment 1 shall document the following:

- Identification of well
- Well depth
- Static water level depth and measurement technique
- Presence of immiscible layers and detection method
- Well yield
- Purge volume and pumping rate
- Time that the well was purged
- Collection method for immiscible layers
- Sample identification numbers
- Well evacuation procedure/equipment
- Sample withdrawal procedure/equipment

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- Date and time of collection
- Well sampling sequence
- Types of sample containers used and sample identification numbers
- Preservative(s) used
- Parameters requested for analysis
- Field analysis data
- Sample distribution and transporter
- Field observations on sampling event
- Name of collector
- Climatic conditions including air temperature

8.0 Quality Control and Assurance

8.1 Monitoring well sampling activities must incorporate quality control measures to ensure that:

- Samples are representative of aquifer conditions and not standing well water.
- Proper decontamination procedures have been followed there is no cross contamination between wells or sites.
- Samples are collected in a method consistent with the analyses to be performed.
- Samples are transported to the laboratory following proper chain of custody (COC) procedures.

8.2 Quality control measures typically include:

- Calibration of monitoring equipment before sampling begins each day, and checking monitoring equipment with a standardized calibration solution at the end of the day.
- Following COC procedures, including keeping custody of the samples at all times, and properly filling out and relinquishing the COC to the laboratory.
- Collecting all required field quality control samples for laboratory analysis.

8.3 These quality control measures provide:

- A level of confidence that the data quality objectives (DQOs) for the project are achieved.

9.0 Records, Data Analysis, Calculations

Information collected during monitoring well sampling shall be documented on the groundwater sampling log form in indelible ink (Attachment 1). Copies of this information shall be sent to the **Project Manager** for the project files.

10.0 Attachments or References

10.1 Attachment 1 – Groundwater Sampling Log.

10.2 Attachment 2 – Low Flow Sampling Using Peristaltic Pump.

10.3 ASTM Standard D5088. 2008. *Standard Practice for Decontamination of Field Equipment Used at Waste Sites.* ASTM International, West Conshohocken, PA. 2008. DOI: 10.1520/D5088-02R08. www.astm.org.

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10.4 Environmental Protection Agency, United States (EPA). 1982. *Handbook for Sampling and Sample Preservation of Water and Wastewater.* EPA-600/4-82-029. Cincinnati: EPA Office of Research and Development, Environmental Monitoring and Support Laboratory.

10.5 EPA. 1992. *RCRA Groundwater Monitoring Draft Technical Guidance*. EPA/530/R-93/001. Office of Solid Waste. November.

10.6 EPA. 1996. *Ground Water Issue: Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*. EPA/540/S-95/504. Office of Solid Waste and Emergency Response. April.

10.7 EPA. 1997. *Test Methods for Evaluating Solid Waste, Physical/Chemical Method (SW-846)*. 3rd ed., Final Update IIIA. Office of Solid Waste. Online updates at: http://www.epa.gov/epaoswer/hazwaste/test/new-meth.htm.

10.8 NAVSEA T0300-AZ-PRO-010. *Navy Environmental Compliance Sampling and Field Testing Procedures Manual*. August 2009.

10.9 Procedure 3-06, *Equipment Decontamination*.

Author	*Reviewer*	*Revisions (Technical or Editorial)*
Phil Granger, Field Manager	Chris Barr Program Quality Control Manager	Rev 0 – Initial Issue

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Attachment 1

GROUNDWATER SAMPLING LOG

WELL NO.: _____ LOCATION: _____ PROJECT NO: _____

DATE: _____ TIME: _____ CLIMATIC CONDITIONS: _____

STATIC WATER LEVEL: _____ TOTAL DEPTH: _____

WELL PURGING: LENGTH OF SATURATED ZONE: _____ LINEAR FEET

VOLUME OF WATER TO BE EVACUATED: _____ GALS/LINEAR FEET X

_____ LINEAR FEET OF SATURATION X CASING VOLUMES = _____ GALS

METHOD OF REMOVAL: _____ PUMPING RATE: _____

WELL PURGE DATA:

DATE/ TIME	GALLONS REMOVED	pH	SP. COND.	DO	REDOX	TURBIDITY

SAMPLE WITHDRAWAL METHOD: _____

APPEARANCE OF SAMPLE: COLOR _____

TURBIDITY _____

SEDIMENT _____

OTHER _____

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES: _____

NUMBER AND TYPES OF SAMPLE CONTAINERS USED: _____

SAMPLE IDENTIFICATION NUMBER(S): _____

DECONTAMINATION PROCEDURES: _____

NOTES: _____

SAMPLED BY: _____

SAMPLES DELIVERED TO: _____ TRANSPORTERS: _____

DATE: _____ TIME: _____

CAPACITY OF CASING (GALLONS/LINEAR FOOT)
2”-0.16 • 4”-0.65 • 6”-1.47 • 8”-2.61 • 10”-4.08 • 12”-5.87

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Attachment 2

LOW FLOW SAMPLING USING PERISTALTIC PUMP

The following step-by-step procedures describe the process of purging with a peristaltic pump:

1. Cut a length of standard-cleaned Teflon® tubing, equal to the well depth plus an additional 5 to 10 feet. Enough tubing is needed to run from the ground surface up to the top of the well casing and back down to the bottom of the well. This will allow for operation of the pump at all possible water level conditions in the well.
2. Place one end of the tubing into the vacuum side of the peristaltic pump head. Proper sizing of the Teflon® and Silastic® or Tygon® tubing should allow for a snug fit of the Teflon® tubing inside the flexible tubing mounted in the pump head.
3. Run a short section of tubing (does not have to be Teflon®) from the discharge side of the pump head to a graduated bucket.
4. Place the free end of the Teflon® tubing into the well until the end of the tubing is just below the surface of the water column.
5. Secure the Teflon® tubing to the well casing or other secure object using electrician's tape or other suitable means. This will prevent the tubing from being lost in the well should the tubing detach from the pump head.
6. Turn on the pump to produce a vacuum on the well side of the pump head and begin the purge. Observe pump direction to ensure that a vacuum is being applied to the purge line. If the purge line is being pressurized, either switch the tubing at the pump head or reverse the polarity of the cables on the pump or on the battery.
7. If the pumping rate exceeds the recovery rate of the well, continue to lower the tubing into the well, as needed, until the drawdown stabilizes or the well is evacuated to dryness. If the pump is a variable speed peristaltic pump, and the water level in the well is being drawn down, reduce the speed of the pump in an attempt to stabilize the drawdown. If the well can be purged without evacuating the well to dryness, a sample with greater integrity can be obtained.
8. For wells which are not evacuated to dryness, particularly those with recovery rates equal to or very nearly equal to the purge rate, there may not be a complete exchange and removal of stagnant water in that portion of the water column above the tubing intake. For this reason, it is important that the tubing intake be placed in the very uppermost portion of the water column while purging.

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Appendix C
CERCLA Documentation Process and RCRA Facility Closure Comparison

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Appendix C
CERCLA Documentation Process and RCRA Facility Closure Comparison

CERCLA	RCRA	REMARKS
Draft Remedial Investigation (RI) Work Plan Final RI Work Plan	Closure Plan (Interim Status Facility) • Facility Information • Waste Description • Soil Sampling • Groundwater Sampling • Analytical Methods • Soil Removal Procedures 45-day Public Notice Approval of Closure Plan	Application for Open Burn/Open Detonation Unit Permit was submitted in June 1988. The Closure Plan is a component of the Part B Application. Public Notice of Permit Actions and Public Comment period applies to a Draft Permit. Process for Closure Plan approval and associated requirements must be agreed upon between DTSC and Navy. RI Work Plan and RI Report will undergo BCT review.
RI Field Work Implementation	Implementation of Closure Plan	
Final RI Report		
Feasibility Study (FS) *Draft Final Proposed Plan (PP)*	*Post-Closure Plan* *Draft Permit* *45 day Public Notice*	*FS and PP documents will undergo BCT review. The Draft Final PP will also be made available for public review/comments.*
*Record of Decision (ROD)/*No Further Action (NFA) Decision Document	*Issuance of Post Closure Permit/*Closure Certification Report	*The ROD will undergo BCT review and public review/comments.*
Remedial Design (RD) *Remedial Action (RA)* *Operation and Maintenance (O&M)*	*Implementation of Post Closure Plan*	
Long Term Monitoring (LTM) Site Close-out	*Post-Closure Certification Report*	

Note:
Italicized tasks will be conducted only if required.
BCT = BRAC (Base Realignment and Closure) Cleanup Team
DTSC = Department of Toxic Substances Control

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Appendix D
Material Safety Data Sheets

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Electron Donor Solution

Section 1: Chemical Product and Company Identification

Product Name: Electron Donor Solution Extended Release
Catalog Codes: EDS-ER
CAS#: 8001-22-7
TSCA: TSCA 8(b) inventory: Soybean oil
HMIS Code: H F R P: 10 0 A
Trade Name and Synonyms: EDS-ER
Chemical Family: Glyceride Oils

Contact Information:
Tersus Environmental, LLC
109 E. 17th Street, Suite #3880
Cheyenne, WY 82001
Ph: 307.638.2822 • info@tersusenv.com
www.tersusenv.com
For emergency assistance, call: 919.638.7892

Section 2: Composition and Information on Ingredients

COMPONANT	CAS #	OSHA TWA	OSHA STEL	ACGIH TWA	ACGIH STEL
Soybean Oil	8001-22-7	---	10 mg/m^3	---	---
Vegetable Oil Derived Fatty Acid Esters	Confidential	---	---	---	---

HAZARDOUS INGREDIENTS: NONE AS DEFINED UNDER THE U.S. OSHA HAZARD COMMUNICATION STANDARD (29 CFR 1910.1200) OR THE CANADIAN HAZARDOUS PRODUCTS. ACT S.C. 1987, C.30 (PART 1).

THE PRECISE COMPOSITION OF THIS PRODUCT IS PROPRIETARY INFORMATION. A MORE COMPLETE DISCLOSURE WILL BE PROVIDED TO A PHYSICIAN IN THE EVENT OF A MEDICAL EMERGENCY.

SARA HAZARD: NONE NOTED (SECTION 311/312) TITLE III SECTION 313 - NOT LISTED
All components of this product are listed on the TSCA registry.

Section 3: Physical/Chemical Characteristics

BOILING RANGE: Not applicable VAPOR DENSITY: Exceeds 1.0

SPECIFIC GRAVITY (H20=1.0): 0.93 VAPOR PRESSURE: Not applicable

PERCENT VOLATILE BY VOLUME: 0% SOLUBILITY IN WATER: Miscible

EVAPORATION RATE: Not applicable
APPEARANCE AND ODOR: A pale yellow, oily liquid - only a faint odor.
WEIGHT PER GALLON: 7.7 lbs. at 60F.

Section 4: Fire and Explosion Data

FLAMMABILITY CLASSIFICATION: Combustible Liquid - Class IIIB.
FLASHPOINT: Greater than 550 F (288 C).
METHOD USED: Tag Closed Cup.
EXTINGUISHING MEDIA: CO2, dry chemical, foam, sand.
SPECIAL FIREFIGHTING PROCEDURES: Avoid use of water as it may spread fire by dispersing oil. Use water to keep fire-exposed containers cool. Water spray may be used to flush spills away from fire.

UNUSUAL FIRE AND EXPLOSION HAZARDS: Rags soaked with any oil or solvent can present a fire hazard and should always be stored in UL Listed or Factory Mutual approved, covered containers. Improperly stored rags can create conditions that lead to oxidation. Oxidation, under certain conditions can lead to spontaneous combustion.

Section 5: Reactivity Data

STABILITY: Generally stable. Spontaneous combustion can occur. See Unusual Fire and Explosion Procedures, Section IV.

CONDITIONS TO AVOID: High surface area exposure to oxygen can result in polymerization and release of heat.

INCOMPATABILITY (MATERIALS TO AVOID): Avoid contact with strong oxidizing agents.

HAZARDOUS DECOMPOSITIONS OR BY-PRODUCTS: Decomposition may produce carbon dioxide and carbon monoxide.

HAZARDOUS POLYMERIZATION: Will not occur.

Section 6: Health Hazard Data

THRESHHOLD LIMIT VALUE: As a liquid - none. As oil mist - 10 mg/m3 total particulate.

INHALATION HEALTH RISKS AND SYMPTOMS OF EXPOSURE: Excessive inhalation of oil mist may affect the respiratory system. Oil mist is classified as a nuisance particulate by ACGIH.

SKIN ABSORPTION HEALTH RISKS AND SYMPTOMS OF EXPOSURE: Not classified as a primary skin irritant or corrosive material. Sensitive individuals may experience dermatitis after long exposure of oil on skin.

HEALTH HAZARDS (ACUTE AND CHRONIC): Acute: none observed by inhalation. Chronic: none reported.

EMERGENCY AND FIRST AID PROCEDURES FOR:

SKIN CONTACT: May be removed from skin by washing with soap and warm water.

EYE CONTACT: Immediately flush eyes with plenty of cool water for at least 15 minutes. Do NOT let victim rub eyes.

INHALATION: Immediately remove exposed individual to fresh air source. If victim has stopped breathing give artificial respiration, get medical attention immediately.

Section 7: Precautions for Safe Handling and Use

ENVIRONMENTAL PRECAUTIONS: Where large spills are possible, a comprehensive spill response plan should be developed and implemented.

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED: Wear appropriate respiratory protection and protective clothing as described in section VIII. Depending on quantity of spill: (a) Small spill - add solid adsorbent, shovel into disposable container and wash the area. Clean area with detergent. (b) Large spill - Squeegee or pump into holding container. Clean area with detergent. In the event of an uncontrolled release of this material, the user should determine if this release is reportable under applicable laws and regulations.

WASTE DISPOSAL METHOD: All recovered material should be packaged, labeled, transported, and disposed or reclaimed in accordance with local, state, and federal regulations and good engineering practices.

Section 8: Control Measures

RESPIRATORY PROTECTION: Not normally needed. A qualified health specialist should evaluate whether there is a need for respiratory protection under specific conditions.

VENTILATION: Handle in the presence of adequate ventilation. Intermittent clean air exchanges recommended, but not required.

PROTECTIVE GLOVES: Not normally needed. However, protective clothing is always recommended when handling chemicals.

EYE PROTECTION: Eye protection is always recommended when handling chemicals. Wear safety glasses meeting the specifications established in ANSI Standard Z87.1.

Section 9: Special Precautions

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE: Store away from flame, fire, and excessive heat.

Section 10: Disposal Considerations

General Information: Do not discharge into drains, watercourses or onto the ground. Discharge, treatment, or disposal may be subject to national, state, or local laws. Empty containers may contain product residues.

Disposal Methods: No specific disposal method required.

Container: Since emptied containers retain product residue, follow label warnings even after container is emptied.

Section 11: Transportation Information

DOT Not regulated.
TDG Not regulated.
IATA Not regulated.
IMDG Not regulated.

Section 12: Other Information

Hazard Ratings

	Health Hazard	Fire Hazard	Instability	Special Hazard
NFPA	1	1	0	NONE

Hazard rating: 0 - Minimal; 1 - Slight; 2 - Moderate; 3 - Serious; 4 - Severe
NFPA Label colored diamond code: Blue - Health; Red - Flammability; Yellow - Instability; White - Special Hazards

	Health Hazard	Flammability	Physical Hazard	Personal Protection
HMIS	1	1	0	--

Hazard rating: 0 - Minimal; 1 - Slight; 2 - Moderate; 3 - Serious; 4 - Severe
HMIS Label colored bar code: Blue - Health; Red - Flammability; Orange - Physical Hazards; White - Special

Section 13: Disclaimer and/or Comments

We suggest that containers be either professionally reconditioned for re-use by certified firms or properly disposed of by certified firms to help reduce the possibility of an accident. Disposal of containers should be in accordance with applicable federal, state and local laws and regulations. "Empty" drums should not be given to individuals.

The conditions of handling, storage, use and disposal of the product are beyond our control and may be beyond our knowledge. For this and other reasons, we do not assume responsibility and expressly disclaim liability for loss, damage or expense arising out of or in any way connected with the handling, storage, use or disposal of the product.

The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no event shall Tersus Environmental be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential or exemplary damages, howsoever arising, even if Tersus Environmental has been advised of the possibility of such damages.

EDS-ER™

Water Mixable Oils for Enhanced Anaerobic Bioremediation

It is time to upgrade your emulsified vegetable oil (EVO) to EDS-ER, the next evolution in enhanced bioremediation. EDS-ER (electron donor solution – extended release) is long lasting water mixable oil, designed to release bio-available hydrogen over a period of 3 to 5 years. EDS-ER with a neutral pH has an expected shelf life in excess of two years. Unlike water-based EVO products, EDS-ER is not affected by freezing temperatures (Freezing Point -4 °F (-20 °C)).

Vegetable oils are hydrophobic and tend not to dissolve in or mix with water. To improve the distribution, some suppliers of electron donors add emulsifiers to the oil and mix the solution with water. The electron donor is packaged as an oil-in-water emulsion containing 25 to 50% water. As these EVO products are commonly sold on a $/lb basis, the buyer is purchasing water. To address sustainability concerns of shipping water to project sites, short shelf life and freeze thaw issues, Tersus Environmental has developed an electron donor family of water mixable oils.

Our Product

EDS-ER (electron donor solution – extended release) by Tersus Environmental is a vegetable oil based water mixable oil that self emulsifies on contact with water. EDS-ER contains no water (reduced shipping costs) and is 100% fermentable. There is no water within the formulation. The cost for shipping the electron donor to the project site may be reduced by as much as 50%. The benefit to you and your client is that we offer a lower cost solution to help you close the site.

Purpose

EDS-ER is a simple, safe, low-cost solution for the bioremediation of halogenated compounds (e.g., PCE, TCE, DCE, VC, TCA, CT, etc.), perchlorate, explosives such as aromatic nitrates, energetic munitions residuals, nitrates, acids, radionuclides, select oxidized heavy metals, and other contaminants.

Configuration

EDS-ER applications are easily configured and tailored to meet site-specific conditions. Configurations include applications in grids, barriers and excavations. Because of its low viscosity, EDS-ER can be applied to the subsurface with direct-push injection, hollow-stem auger, existing wells or re-injection wells.

Benefits

- 100% fermentable – contains no water
- Completely water mixable which minimizes the number of injection points for low permeability structures, reducing overall capital costs
- Easily mixes with water for economical application
- Controlled release of electron donors for up to five years
- Food-grade carbon
- Low total dissolved solids to comply with secondary water quality requirements for amendments with low salt content
- Conforms to EPA's EPP (Environmentally Preferable Purchasing) and USDA biobased criteria
- No operations and maintenance
- Clean, low-cost, non-disruptive application (e.g., direct-push, wells and excavations)
- Green sustainable chemistry, made from renewable crop-based oils
- Low cost transportation when compared to other electron donors
- Long shelf life - shelf life unrefrigerated > 2 years
- Freezing Point -4 °F (-20 °C)

Offers Cost Savings

Our EDS-ER technology has the potential to offer significant cost savings to the groundwater remediation industry. The passive nature of EDS-ER eliminates the large capital and operations/maintenance costs associated with active engineered systems. EDS-ER offers a faster and lower cost alternative to drawn out natural attenuation approach.

Longevity

A single EDS-ER application provides a controlled release of electron donors for periods of up to 3 to 5 years, under optimal conditions.

Field Applications

Because of its low viscosity and longevity, EDS-ER is an ideal substrate for injection using direct-push technology for source area, plume and reactive barrier applications. The low viscosity allows a greater volume of EDS-ER to be applied in a shorter period and increases the substrate delivery radius per point. The result is fewer injection points and overall shorter delivery time requirements per site. EDS-ER is also ideal for injection into the subsurface through injection wells or used in soil mixing and excavation projects.

Product Specifications

- Vegetable oil based, 100% fermentable – contains no water
- Neutral pH when mixed with water
- Shelf Life Unrefrigerated > 2 years

Packaging Options

- 55-gallon poly drums
- 275-gallon IBC containers
- 3,000 - 5,000 gallon tankers

Convergence of Gas inFusion Technology & *In Situ* Remediation Technologies

Adding hydrogen-enriched water can enhance the performance Tersus' EDS-ER and other electron donor substrates. Infusing hydrogen into water with the inVentures HiSOC or gPRO technology can reduce the demand for the carbon-based electron donor by as much as 50%. Simply add the hydrogen-infused water to EDS-ER for dilution, pre-conditioning, recirculation or chase water. Further, you can inject the hydrogen-enriched water with your bioaugmentation cultures.

About Us

What if we always settled for the first technology that came along?
Then we would have never gotten to where we are today.

We Develop & Market Innovative, Sustainable, Green Technologies. Tersus Environmental also provides global sales management and marketing services for inVentures Technologies' complete family of groundwater remediation products based on the worldwide-patented Gas inFusion technology, which allows for supersaturated levels of dissolved gas into liquids.

Innovative Sustainable Green Technologies
Tel: 919.453.5577 • info@tersusenv.com
tersusenv.com

Global Supplier of Gas inFusion Technology
Tel: 647.477.2394 • U.S. Tel: 646.688.4426
iSOCinfo.com • gPROinfo.com

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Rev: 14 February 2013

BATORY FOODS

batoryfoods.com
800.367.6975

MATERIAL SAFETY DATA SHEET
CORN SYRUPS (GLUCOSE SYRUPS) & CORN SYRUP/SUCROSE BLENDS

Section I – Chemical Product and Company Identification

Product Name(s) Corn Syrups (Glucose Syrups) and Sucrose/Corn Syrup Blends
CAS# 8029-43-4
Distributor – Batory Foods
1700 Higgins Rd. Suite 300
Des Plaines, IL 60018
Emergency # -- 800-367-6975

Section II – Composition

Hazardous Components – None
% Comp – Not required
OSHA PEL – N/A
ACGIH TLV – N/A

Section III – Hazard Identification

Route or entry
- Eyes – yes
- Indigestion – yes
- Skin – yes
- Inhalation – yes

Acute Health Hazards – None
Chronic Health Hazards – None
Medical Conditions Generally Aggravated by the Exposure – None

Section IV – First Aid Measures

Eyes – Flush with water
Ingestion – None
Inhalation – Treat symptomatically is breaking is abnormal
Skin – wash with water

Section V – Fire Fighting Measures

Flash Point – N/A
Flammable Limits – N/A
Extinguishing Media – water foam or carbon dioxide
Special Fire Fighting Procedures – N/A
Special Fire & Explosion Hazards – N/A
NFPA Hazard Code – Health = 0
Flammability = 0
Reactivity = 0

MATERIAL SAFETY DATA SHEET
CORN SYRUPS (GLUCOSE SYRUPS) & CORN SYRUP/SUCROSE BLENDS

Section VI – Accidental Release Measures

Spill or Leak Procedures – Wash with warm water and sweep up into DOT approved containers.
Follow state & municipal requirements for non-hazardous waste disposal.
Neutralizing Chemicals – None

Section VII – Exposure Controls/Personal Protection

Respiratory – N/A
Protective Gloves – N/A
Ventilation – N/A
Eye Protection – N/A
Work/Hygiene – Good Housekeeping
Other – N/A

Section VIII – Physical & Chemical Properties

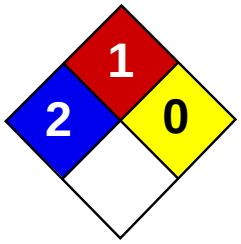
Appearance & Odor – Water white to pale amber liquid; odorless
Boiling Point -- 226°
Specific Gravity – 1.42 @ 100° F
Vapor Density – N/A
Evaporation Rate – N/A
Solubility – 100%
Vapor Pressure – N/A

Section IX – Stability & Reactivity

Stability – Stable
Incompatibility – Not reactive
Conditions to Avoid – N/A
Hazardous Polymerization – Will not occur
Hazardous Decomposition or Byproducts – None

Section X – Toxicological Information

Toxicity Hazard Rating – Not listed under SARA Title III
OSHA – Non-Hazardous



Health	2
Fire	1
Reactivity	0
Personal Protection	E

Material Safety Data Sheet
Cyanocobalamin MSDS

Section 1: Chemical Product and Company Identification

Product Name: Cyanocobalamin

Catalog Codes: SLC5008, SLC2218

CAS#: 68-19-9

RTECS: GL7030000

TSCA: TSCA 8(b) inventory: Cyanocobalamin

CI#: Not available.

Synonym: Vitamin B12; Cobinamide, cyanide phosphate 3'-ester with 5,6-dimethyl-1-alpha-Dribofuranosylbenzimidazole, inner salt

Chemical Formula: C63H88CoN14O14P

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call: 1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Cyanocobalamin	68-19-9	100

Toxicological Data on Ingredients: Cyanocobalamin LD50: Not available. LC50: Not available.

Section 3: Hazards Identification

Potential Acute Health Effects:
Very hazardous in case of ingestion. Hazardous in case of skin contact (irritant), of eye contact (irritant), of inhalation. Slightly hazardous in case of skin contact (permeator).

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. The substance is toxic to lungs, mucous membranes. Repeated or prolonged exposure to the substance can produce target organs damage.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Cold water may be used. Do not use an eye ointment. Seek medical attention.

Skin Contact:
After contact with skin, wash immediately with plenty of water. Gently and thoroughly wash the contaminated skin with running water and non-abrasive soap. Be particularly careful to clean folds, crevices, creases and groin. Cold water may be used. Cover the irritated skin with an emollient. If irritation persists, seek medical attention. Wash contaminated clothing before reusing.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek medical attention.

Inhalation: Allow the victim to rest in a well ventilated area. Seek immediate medical attention.

Serious Inhalation: Not available.

Ingestion:
Do not induce vomiting. Loosen tight clothing such as a collar, tie, belt or waistband. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek immediate medical attention.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: May be combustible at high temperature.

Auto-Ignition Temperature: Not available.

Flash Points: Not available.

Flammable Limits: Not available.

Products of Combustion: These products are carbon oxides (CO, CO2), nitrogen oxides (NO, NO2...). Some metallic oxides.

Fire Hazards in Presence of Various Substances: Not available.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions:
SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use water spray, fog or foam. Do not use water jet.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

Precautions:
Keep away from heat. Keep away from sources of ignition. Empty containers pose a fire risk, evaporate the residue under a fume hood. Ground all equipment containing material. Do not breathe dust. Wear suitable protective clothing In case of insufficient ventilation, wear suitable respiratory equipment If you feel unwell, seek medical attention and show the label when possible. Avoid contact with skin and eyes

Storage:
Keep container dry. Keep in a cool place. Ground all equipment containing material. Keep container tightly closed. Keep in a cool, well-ventilated place. Combustible materials should be stored away from extreme heat and away from strong oxidizing agents.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection:
Splash goggles. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid.

Odor: Not available.

Taste: Not available.

Molecular Weight: 1355.39 g/mole

Color: Not available.

pH (1% soln/water): Not available.

Boiling Point: Decomposes.

Melting Point: 102.5°C (216.5°F)

Critical Temperature: Not available.

Specific Gravity: Not available.

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water.

Solubility: Partially soluble in cold water.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Not available.

Incompatibility with various substances: Not available.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: Not available.

Polymerization: No.

Section 11: Toxicological Information

Routes of Entry: Eye contact. Inhalation. Ingestion.

Toxicity to Animals:
LD50: Not available. LC50: Not available.

Chronic Effects on Humans: The substance is toxic to lungs, mucous membranes.

Other Toxic Effects on Humans:
Very hazardous in case of ingestion. Hazardous in case of skin contact (irritant), of inhalation. Slightly hazardous in case of skin contact (permeator).

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: Not available.

Special Remarks on other Toxic Effects on Humans: Not available.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are more toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations: TSCA 8(b) inventory: Cyanocobalamin

Other Regulations: OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200).

Other Classifications:

WHMIS (Canada): CLASS D-2A: Material causing other toxic effects (VERY TOXIC).

DSCL (EEC): R36/38- Irritating to eyes and skin.

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 1

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 2

Flammability: 1

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Splash goggles.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

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Last Updated: 05/21/2013 12:00 PM

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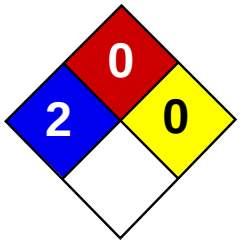

Health	2
Fire	0
Reactivity	0
Personal Protection	E

Material Safety Data Sheet
Sodium bromide MSDS

Section 1: Chemical Product and Company Identification

Product Name: Sodium bromide

Catalog Codes: SLS3820, SLS1600

CAS#: 7647-15-6

RTECS: VZ3150000

TSCA: TSCA 8(b) inventory: Sodium bromide

CI#: Not available.

Synonym: Bromide salt of sodium

Chemical Name: Sodium Bromide

Chemical Formula: NaBr

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call: 1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Sodium bromide	7647-15-6	100

Toxicological Data on Ingredients: Sodium bromide: ORAL (LD50): Acute: 3500 mg/kg [Rat]. 7000 mg/kg [Mouse].

Section 3: Hazards Identification

Potential Acute Health Effects:
Hazardous in case of eye contact (irritant), of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant).

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. Repeated or prolonged exposure is not known to aggravate medical condition.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. Get medical attention.

Skin Contact:

Wash with soap and water. Cover the irritated skin with an emollient. Get medical attention if irritation develops. Cold water may be used.

Serious Skin Contact: Not available.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Serious Inhalation: Not available.

Ingestion:
Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention if symptoms appear.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Non-flammable.

Auto-Ignition Temperature: Not applicable.

Flash Points: Not applicable.

Flammable Limits: Not applicable.

Products of Combustion: Not available.

Fire Hazards in Presence of Various Substances: Not applicable.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions: Not applicable.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

Precautions:
Do not ingest. Do not breathe dust. Avoid contact with eyes. Wear suitable protective clothing. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Keep away from incompatibles such as oxidizing agents, acids.

Storage: Keep container tightly closed. Keep container in a cool, well-ventilated area. Do not store above 25°C (77°F).

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection:
Splash goggles. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid.

Odor: Not available.

Taste: Not available.

Molecular Weight: 102.91 g/mole

Color: Not available.

pH (1% soln/water): 6.5-8.0

Boiling Point: 1390°C (2534°F)

Melting Point: 755°C (1391°F)

Critical Temperature: Not available.

Specific Gravity: 3.21 (Water = 1)

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water, methanol.

Solubility:
Easily soluble in cold water, hot water. Soluble in methanol. 1 g dissolves in 1.1 ml of water. 1 g dissolves in about 16 ml of alcohol. 1 g dissolves in 6 ml of methanol

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Incompatible materials, moisture

Incompatibility with various substances: Reactive with oxidizing agents, acids.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity:
Absorbs moisture from the air but is not deliquescent. Hygroscopic. Also incompatible with alkaloidal and heavy metal salts, and Bromine Trifluoride.

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Inhalation. Ingestion.

Toxicity to Animals: Acute oral toxicity (LD50): 3500 mg/kg [Rat].

Chronic Effects on Humans: Not available.

Other Toxic Effects on Humans:
Hazardous in case of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant).

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans:
May cause adverse reproductive effects (male and female effects on fertility and effects on newborns and fetotoxicity) based on animal data Human: passes the placental barrier, detected in maternal milk.

Special Remarks on other Toxic Effects on Humans:
Acute Potential Health Effects: Skin: May cause mild skin irritation. Eyes: Causes eye irritation. Inhalation: May cause respiratory tract irritation. Ingestion: May cause gastrointestinal tract irritation with nausea and vomiting, abdominal pain, constipation. Bromide poisoning following acute ingestion is more rare and may affect the central nervous system (CNS depression - somnolence, confusion, ataxia, coma and other symptoms similar to chronic ingestion), cardiovascular system (hypotension, tachycardia), kidneys (acute renal failure, urinary incontinence), and respiration (acute respiratory distress syndrome). It may also cause eye disturbances such as mydriasis and nystagmus, disturbances of apparent color of objects, blurring or indistinctness of vision, apparent movement or wiggling and change in apparent size of objects, large pupils, subnormal reaction to light, diplopia, and photophobia. Chronic Potential Health Effects: Skin: Prolonged or repeated skin contact may cause skin rashes. Eyes: Prolonged or repeated eye contact may cause blepharitis, and conjunctivitis. Prolonged or repeated ingestion may cause skin rashes (bromoderma, acne, pyoderma gangrenosum, erythema multiforme), affect the liver, endocrine system (thyroid), metabolism(anorexia), blood, vision (visual disturbances, permanently decreased vision and may produce a toxic syndrome, "Bromism" which may be characterized by behavior/central nervous symptoms such CNS depression, irritability, headache, confusion, slurred speech, memory loss, lethargy, ataxia, tremor, agitation, delusion, disoriented, paranoia, aggressiveness, hallucinations, mania, fatigue, seizure, neuropathy, muscle weakness, coma. Also, in individuals with chronic bromism, the tongue may have a coated or furred appearance.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The product itself and its products of degradation are not toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations: TSCA 8(b) inventory: Sodium bromide

Other Regulations: EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC):
R36- Irritating to eyes. S2- Keep out of the reach of children. S24/25- Avoid contact with skin and eyes. S46- If swallowed, seek medical advice immediately and show this container or label.

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 0

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 2

Flammability: 0

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Splash goggles.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

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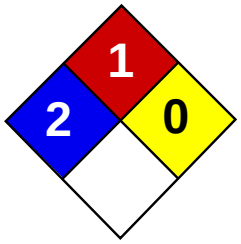

Health	2
Fire	1
Reactivity	0
Personal Protection	E

Material Safety Data Sheet
Fluorescein MSDS

Section 1: Chemical Product and Company Identification

Product Name: Fluorescein

Catalog Codes: SLF1135, SLF1645

CAS#: 2321-07-5

RTECS: LM5075000

TSCA: TSCA 8(b) inventory: Fluorescein

CI#: Not available.

Synonym: CI Solvent Yellow 94; Spiro[isobenzofuran-1(3H),9'-[9H]xanthen]-3-one, 3'6'-dihydroxy-; 2-(6-Hydroxy-3-oxo-(3H)-xanthen-9-yl)benzoic acid; D & C Yellow #7; Fluorescein, alcohol soluble.

Chemical Name: Fluorescein

Chemical Formula: C20H12O5

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call: 1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Fluorescein	2321-07-5	100

Toxicological Data on Ingredients: Fluorescein LD50: Not available. LC50: Not available.

Section 3: Hazards Identification

Potential Acute Health Effects: Hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation.

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Mutagenic for bacteria and/or yeast. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. Repeated or prolonged exposure is not known to aggravate medical condition.

Section 4: First Aid Measures

Eye Contact:

Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention.

Skin Contact:
In case of contact, immediately flush skin with plenty of water. Cover the irritated skin with an emollient. Remove contaminated clothing and shoes. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek medical attention.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Serious Inhalation: Not available.

Ingestion:
Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. If large quantities of this material are swallowed, call a physician immediately. Loosen tight clothing such as a collar, tie, belt or waistband.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: May be combustible at high temperature.

Auto-Ignition Temperature: Not available.

Flash Points: CLOSED CUP: Higher than 93.3°C (200°F).

Flammable Limits: Not available.

Products of Combustion: These products are carbon oxides (CO, CO2).

Fire Hazards in Presence of Various Substances:
Slightly flammable to flammable in presence of open flames and sparks, of heat. Non-flammable in presence of shocks.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions:
SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use water spray, fog or foam. Do not use water jet.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

Precautions:

Keep locked up.. Keep away from heat. Keep away from sources of ignition. Empty containers pose a fire risk, evaporate the residue under a fume hood. Ground all equipment containing material. Do not breathe dust. Wear suitable protective clothing. In case of insufficient ventilation, wear suitable respiratory equipment. If you feel unwell, seek medical attention and show the label when possible. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents.

Storage: Keep container tightly closed. Keep container in a cool, well-ventilated area. Do not store above 24°C (75.2°F).

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection:
Splash goggles. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid. (Solidcrystalline powder.)

Odor: Not available.

Taste: Not available.

Molecular Weight: 332.31 g/mole

Color: Yellow (Yellowish-Red) to Red.

pH (1% soln/water): Not applicable.

Boiling Point: Not available.

Melting Point: 315°C (599°F)

Critical Temperature: Not available.

Specific Gravity: Not available.

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water, methanol, acetone.

Solubility:
Easily soluble in acetone. Soluble in methanol, hot alcohol, glacial acetic acid, alkali hydroxides, and carbonates. Insoluble in cold water, diethyl ether, petroleum ether, benzene.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Excess heat, excess dust generation, incompatible materials

Incompatibility with various substances: Reactive with oxidizing agents.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Inhalation. Ingestion.

Toxicity to Animals:
LD50: Not available. LC50: Not available.

Chronic Effects on Humans: MUTAGENIC EFFECTS: Mutagenic for bacteria and/or yeast.

Other Toxic Effects on Humans: Hazardous in case of skin contact (irritant), of ingestion, of inhalation.

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: Not available.

Special Remarks on other Toxic Effects on Humans:
Acute Potential Health Effects: Skin: May cause skin irritation. Eyes: Causes eye irritation. Ingestion: May cause irritation of the gastrointestinal (digestive) tract. Inhalation: may cause respiratory tract irritation. The toxicological properties of this substance have not been fully investigated.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The product itself and its products of degradation are not toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:
Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations:
TSCA 8(b) inventory: Fluorescein SARA 313 toxic chemical notification and release reporting: Fluorescein

Other Regulations: EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC):
R36/38- Irritating to eyes and skin. S24/25- Avoid contact with skin and eyes. S37- Wear suitable gloves. S45- In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 1

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 2

Flammability: 1

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Splash goggles.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

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Last Updated: 05/21/2013 12:00 PM

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Appendix E
Response to Comments

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Comments by: *Quang Than, Remedial Project Manager, Brownfields and Environmental Restoration Program, California Department of Toxic Substances Control. Letter dated August 24, 2012*

No.	Comment	Response
1.	The owner(s) of the off-Station property need to be identified and the process the Department of the Navy (DON) follows to achieve land use restrictions on this property needs to be described in more detail.	As discussed and concurred upon at the 20 February 2013 Base Realignment and Closure (BRAC) Cleanup Team (BCT) meeting, to expedite the construction phase, subsequent versions of the Land Use Control (LUC) Remedial Design (RD) will be issued as a separate document. Therefore, responses to comments (RTCs) relating to institutional controls and the LUC RD will be provided at a later date.
2.	The Federal Aviation Administration (FAA) recently transferred ownership of property it received from the DON to the Federal Bureau of Investigation (FBI). The WP needs to completely address this transfer and revisions need to be globally made to reflect this transfer. Additionally, DTSC requests that a copy of the Memorandum of Understanding (MOU) between the FAA and the FBI be provided in the WP.	The following portions of the Remedial Design/ Remedial Action Work Plan (RD/RAWP) will be revised to reflect the ownership change from the Federal Aviation Administration (FAA) to the Federal Bureau of Investigation (FBI): 1. Main text, Sections 2.2, 3.4.1, 6.8, 7.4, and 8.3.1. 2. Main text, Figures 2-2 through 2-4, 3-1 through 3-4, 3-7 through 3-11, 6-1, 6-3, 6-5 through 6-7, 7-1, 8-3, and 8-4. 3. Attachment A, Section 14.1.1 As indicated in RTC #1 above, the revisions to reflect ownership change from the FAA to the FBI in the LUC RD (Attachment B) will be incorporated at a later date. In addition a copy of the Memorandum of Understanding (MOU) between FAA and the FBI will also be appended to the LUC RD.
3.	Page 2-2, Section 2.3, Areas Requiring Institutional Controls [Attachment B]: a) First sentence: Please revise this sentence to state that the "ICs will remain in place until it is determined by the DON and the FFA signatories that the contamination remaining at the property is at	Please see RTC #1, a response to this comment will be provided at a later date.

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	levels that allow for unrestricted use of the property" or in the alternative clarify that the RGs established for the site were set at levels that will allow for unrestricted use. b) Second sentence: Please change the end of the sentence to read, "…due to potential contact with or use of groundwater."	
4.	Page 4-1. Section 4.1. Land Use Control Restrictions and Implementation –IRP Site 1. First sentence: See Comment #3a above. This should be a global change in the document.	Please see RTC #1, a response to this comment will be provided at a later date.
5.	Page 4-1. Section 4.1.1.1: There should be a general restriction prohibiting activities that may expose contaminated groundwater.	Please see RTC # 1, a response to this comment will be provided at a later date.
6.	Page 4-1. Section 4.1.1.2. Land Use Restrictions Following Property Transfer. First sentence: It is not clear why item #4 in Section 4.1.1.1 was made a separate restriction and requires only Navy approval. Perhaps that is acceptable while the DON still retains the property, but following transfer, the approval process should include all of the FAA signatories. The items considered in item #4 of the restrictions are components of the remedy and as such are covered by item #1 of the restrictions.	Please see RTC #1, a response to this comment will be provided at a later date.
7.	Page 4-1, Section 4.1.1.2: The discussion on Fed-to-Fed transfers should include a discussion that a state Land Use Covenant will be required at the time a successor Federal entity transfers the property to a non-Federal entity (the DON/FAA MOU does not appear to contain this discussion and DTSC suggests that the FAA/FBI MOU, which DTSC has not seen, should include it). The discussion should also include information on what mechanism will be in place with a Federal entity successor to address the restrictions and requirement (e.g., annual reporting. etc.). In addition, DTSC's land use covenant regulation (California Code of Regulations section 67391.1) requires in subdivision	Please see RTC #1, a response to this comment will be provided at a later date.

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	(e)(2) that "[w]henever the Department determines that it is not feasible to record a land use covenant for property owned by the federal government, such as transfers from one .federal agency to another, the Department and federal government shall use other mechanisms to ensure that future land use will be compatible with the levels of hazardous materials, hazardous wastes or constituents, or hazardous substances which remain on the property. Examples include: amendments to the federal government facility master plan, physical monuments, or agreements between the federal government facility and the Department." DTSC assumes that the DON is retaining ultimate responsibility for the integrity of the remedy and therefore the IC obligations. If that is the case, any MOU addressing transfers between Federal entities in the future should contain provisions for the items discussed in this comment, and Section 4.1.1.2 should include a provision that the DON will be responsible for providing the other FFA signatories a copy of future MOUs or other documents transferring control of the property to successor Federal entities.	
8.	Page 4-4, Section 4.1[.]4, Off-Station Property: This section appears to be inadequate to protect human health and the environment without further detail to describe what process will be agreed to between the DON (along with the other FFA signatories), and the named entities. Have these entities committed to undertake these obligations and agreed to have DON and FFA signatory review/approval over permits in these areas? Does the DON have commitments that these entities will agree to the reporting requirements that are necessary? The description in this section is very ambiguous when it is being proposed as a component of the remedy. Specific details are needed at the RD stage and this section does not offer the detail that is necessary.	Please see RTC #1, a response to this comment will be provided at a later date.
9.	Page 5-2, Section 5.3: a) Second bullet: It should refer to the FBI instead of the FAA. It	Please see RTC #1, a response to this comment will be provided at a later date.

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	should also state that the FBI will provide reports to the FFA signatories or to the DON and then the DON will provide the other FFA signatories copies of the report. b) Third bullet: This section does not offer sufficient detail for a LUC RD. It should provide that the DON will negotiate with Off-Station Property owners for access for inspections and monitoring as necessary.	
10.	Page 5-3, Section 5.4.2, Second (should be Third, see Comment #38) bullet. Last sentence: This section should provide that the DON will conduct inspections to ensure the integrity of the remedy.	Please see RTC #1, a response to this comment will be provided at a later date.
11.	Page 6-1, Section 6: This section should also discuss these requirements for the Off-Station property.	Please see RTC #1, a response to this comment will be provided at a later date.
12.	Page 6-2, Section 6.7: This section should provide that a state land use covenant will be required in the event that the property is transferred out of federal control.	Please see RTC #1, a response to this comment will be provided at a later date.
13.	Figure 2: This figure should identify "Off-Station" property. Also, does the ARIC(s) encompass any property identified in the "Transferred Area"? If so, how was that area(s) discussed in the document? It is difficult to tell from the figure who exactly controls areas identified as being in the ARICs. Finally, this figure does not appear to be consistent with Figure 1 in Appendix C (DON/FAA MOU Amendment executed in May 2012). Please explain or correct the inconsistency.	This comment pertains to Figure 2 of the LUC RD (Attachment B). Please see RTC # 1, a response to this comment will be provided at a later date.
14.	DTSC notes that proposed contingency well 02NEW42 would fill a data gap in the area downgradient of the currently mapped Site 2 VOC plume,	Proposed well 02NEW42 will be installed as part of the remedial action and included in the monitoring well network.

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	and the potential discharge of the Site 1 perchlorate plume into the Irvine groundwater basin. The well would be valuable for monitoring both contaminant transport and groundwater elevation patterns south of the probable fault at the mouth of Borrego Canyon. DTSC requests that the well be installed and included in the MNA monitoring network.	The following portions of the RD/RAWP will be revised to reflect the installation of well 02NEW42: 1. Main text, Section 7.3.2, Table 7-3 2. Attachment A (Sampling and Analysis Plan), Table 18-7
15.	DTSC notes that the WP relies (Section 3.1.3, page 3-3) on groundwater data from a report titled Well Installation and Boring Log Submittal Report for Wells 02_NEW02A, 02_NEW07A, 02_NEW26A, and 02_NEW27A, Alton Parkway Extension Project, Irvine, California. May 8, 2012 by Trevet. This report has not been submitted to DTSC. DTSC requests that the report be submitted for review before this draft WP is finalized.	Copies of the *"Final Navy Well Reports for Wells 02NEW02A, 02NEW07A, 02NEW26A, and 02NEW27A in Support of the Alton Parkway Extension Project, Installation Restoration Program Site 2, Former Marine Corps Air Station El Toro, California (May 2012)"* were submitted to Federal Facility Agreement (FFA) signatories on 13 September 2012.
16.	DTSC notes that in the Sampling and Analysis Plan (SAP) Section 11.1.4 Analytic Approach, Decision Rule 2 makes reference to background levels of Total Organic Carbon (TOC). The document should reference the source document for these background levels, and state at least the general order of magnitude of those background levels.	The text will be revised to refer to ambient total organic carbon (TOC) concentrations in lieu of background TOC concentrations. Ambient TOC concentrations will be determined based on results from groundwater samples collected, prior to substrate injection from at least one well at each of the three treatment areas (Source Area, Intermediate Permeable Reactive Barrier [PRB], and Station Boundary PRB). Also see Table 18-1 of the Sampling and Analysis Plan [SAP]).
17.	SAP Section 11.1.4 Analytic Approach, Decision Rule 4 states actions to be taken on observation of a "decreasing trend" in perchlorate concentrations. The document should state how such trends will be measured and documented, for example, by Mann-Kendall trend analysis, linear regression, or some other method.	Perchlorate concentration hydrographs from wells upgradient and downgradient of PRBs will be prepared. Based on an examination of these concentration hydrographs, professional judgment will be used to establish whether decreasing trends exist. As sufficient data become available, Mann-Kendall analysis and other statistical methods will be considered for trend analysis.
18.	Section 7.3: Similar to Comment #17, because MNA at this location will be mainly due to dispersion, dilution, sorption, and volatilization, the	The Sampling and Analysis Schedule (Table 7-3) is adequate to generate sufficient data to be evaluated per the methods

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	process may be slow. In order to be statistically significant in both spatial and temporal trend, appropriate data set will be required. The proposed approach (8 wells, 4 data points/each according to Section 7.3.4.1 and Table 7-3) may not be sufficient to achieve this goal.	proposed in the Data Evaluation (Table 7-2). Please note that Table 7-2 indicates that statistical tests will be initiated after the collection of 3 years of concentration data. Data collected during the first 3 years will be evaluated using non-statistical approaches.
19.	SAP Section 11.1.4 Analytic Approach, Decision Rule 6 is based on verification monitoring of perchlorate for a period of one year. DTSC points out that Southern California is subject to highly variable groundwater recharge depending on winter season precipitation. During pumping tests at Site 2, large changes in groundwater elevation were documented during and after rain events. Since the remaining reservoir of perchlorate is probably in soils that lie in the vadose zone, DTSC requests that, to be acceptable data, the verification monitoring should be performed in a year with at least median rainfall in the Borrego Canyon area. If rainfall is less than median during the verification year, the Navy should propose to resample the wells in the spring of the next year with median or greater rainfall.	Federal Facility Agreement (FFA) signatories will have the opportunity to review and comment on the adequacy of performance monitoring before the transition to verification monitoring as stated in Decision Rule 5. Decision Rule 5 states, "If it is demonstrated to the satisfaction of the regulatory agencies that chemical of concern (COC) concentrations are reduced to levels at or below their respective remediation goals (RGs), verification monitoring will be initiated." Verification monitoring (Decision Rule 6) will not be initiated until several rounds of performance monitoring have been completed and the regulatory agencies concur.
20.	Section 6.10 (and Section 7.6): Similar to Comment #19, this section needs to specify how many verification sampling events are scheduled in the 1-year period.	Two verification monitoring events will be conducted in a 1-year period. Sections 6.10 and 7.6 will be revised as follows to reflect this. The second line of Section 6.10 will be revised as follows: *"The verification monitoring will include two sampling events over a period of 1 year. The purpose of verification monitoring will be to show that perchlorate concentrations remain at or below its RG pursuant to requirements of California Code of Regulations (Cal. Code Regs.), Title (tit.) 22, Section 66264.100(g)(1) determined to be relevant and*

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		appropriate for IRP Site 1 groundwater response action." The second line of Section 7.6 will be revised as follows: *"The verification monitoring will include two monitoring events over a period of one year. The purpose of verification monitoring will be to show that the COC concentrations remain at or below their respective RGs pursuant to requirements of Cal. Code Regs. tit. 22, Section 66264.100(g)(1) determined to be relevant and appropriate for IRP Site 2 groundwater response action."*
21.	For ISB design (Sections 6.4, 6.5, 6.6), an extraction/injection scheme is used to enhance the distribution of substrate. Usually, using extracted groundwater for substrate dilution water (as shown on Figure 6-2) is appropriate. However, the approach to use extracted "contaminated" groundwater as "chase water" may raise a concern. In order to inject contaminated groundwater, the water has to meet the "treatment" requirement (RCRA 3020(b) exemption of reinjection of contaminated groundwater).	Sections 6.4, 6.5, and 6.6 will be revised to state that perchlorate-impacted groundwater will only be used as dilution water for substrate. Perchlorate-impacted groundwater will not be reinjected to propagate substrate distribution (e.g. as chase water).
22.	For ISB monitoring (Section 6.7), the current substrate design of permeable reactive barriers (PRBs) (from Appendix A) was based on the proposed PRB length and width with a safety factor of 3 for emulsified vegetable oil (EVO) and 2 for high-fructose corn syrup (HFCS). It did not take into account the contaminant mass between the PRBs (or between the source area and PRB). Therefore, the longevity of the ability of the PRB to treat upgradient contaminant mass needs to be carefully evaluated. For example, a PRB zone may be established and be able to reduce contaminants below the remediation goals (RGs) in the downgradient wells in a short period of time. But rebound may occur if the PRB cannot sustain treatment of the upgradient contaminants. This also depends on how groundwater migrates and if upgradient source	As shown in Appendix A, for each PRB, the substrate loading estimate is based on the following (taking into account appropriate safety factors): 1. Stochiometric demand of electron acceptors within the proposed treatment area of the PRB, and 2. Stochiometric demand for electron acceptors that will be flowing into the PRB from upgradient area for a period of three years. Performance monitoring will be conducted to evaluate the depletion of substrate over time. If the data evaluation based

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	reduction or PRB treatment would reduce the impact to downgradient PRBs. Therefore, eliminating a well from monitoring just due to meeting the RGs in two monitoring events may miss the potential rebound. Instead, the overall plume condition has to be evaluated (similar to the discussion in Section 7.3.4) to optimize the monitoring program.	on the decision rules presented in the SAP indicates that substrate is no longer present in sufficient quantity to sustain biodegradation, additional rounds of substrate injection will be evaluated. It is anticipated that multiple rounds of substrate injection over several years may be needed for the PRBs to achieve the RGs for perchlorate-impacted groundwater. This will be clarified in Sections 6.4.1, 6.5, and 6.6 of the Work Plan. The monitoring plan presented in Section 6.7 does consider the potential for perchlorate to migrate from upgradient areas at concentrations exceeding its RG, as one of the criteria that will be evaluated to eliminate a well from the monitoring program (see Section 6.7.4 Step #3).
23.	Section 6.7.2: The baseline groundwater monitoring wells (Table 6-12) do not seem to be coordinated with the performance monitoring wells (Tables 6-13 thru 6-16). For example, 01-IW06 and 01-IW07 are monitored for general chemistry, but these two wells are not in the performance monitoring (Table 6-14). Please explain.	The revised Baseline Groundwater Monitoring Plan (Table 6-12) is attached to these RTCs. The baseline plan has been revised to coordinate and be consistent with the performance monitoring plan presented in Tables 6-13 through 6-16. It should be noted that general chemistry parameters will be obtained from wells 01-EW05 and 01-EW07 during both baseline and performance monitoring.
24.	Section 6.7.3/Table 6-13: a) 01-MW229 should be analyzed for total organic compounds (TOC) beyond the first event. Unless there is a good correlation between 01-MW229 and 01-IW01, there will be issues as discussed in Comment #22. Besides, 01-MW229 is a monitoring well, which is a better candidate than an injection well. b) Also, please explain why 01-PZ21A is listed in this table but not 01-PZ21B. Although 01-PZ21B has lower perchlorate concentration, it	(a) TOC refers to total organic carbon. TOC analysis will be added for well 01-MW229 for all performance monitoring rounds shown on Table 6-13. (b) During the 2009-2010 in-situ bioremediation (ISB) pilot study performance monitoring (6 months), no increase in TOC concentrations were observed in well 01-PZ21B in response to substrate injection at well 01-IW01. Therefore, there appears to be no cross connection influence between 01-PZ21B and 01-PZ21A. Additionally, 01-PZ21B is a deeper well collocated with

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	is in the influence zone, and may show cross-connection influence.	01-PZ21A (see Cross-Section A-A' on Figure 3-5).
25.	Section 6.7.3/Table 6-14: It is not clear about the rationale for inclusion of Wells 01-PZ08 and 01-PZ20 in this table. Considering the estimated radii of influence (ROIs) and the fact that these wells are crossgradient of injection well 01-IW14, will monitoring data show any injection effects? If not, do we need an injection well closer to and upgradient of these two wells, especially 01-PZ08?	The wells 01-PZ08 and 01-PZ20 are located within Zone 2 of the IRP Site 1 Source Area. Substrate will be injected into each of these wells as explained in Section 6.4.2.2, Table 6-7 and Figure 6-4 of the Work Plan. Therefore, performance monitoring will be required for these wells to evaluate ISB performance within Zone 2.
26.	Section 6.7.3/Table 6-17: Metal migration is a concern when conditions turn anaerobic and thus selected downgradient well(s) from the injection zone should also test for metals. In addition, perchlorate byproduct (see Comment #27) and biological activities (see Comment #28) may need monitoring.	The RD/RAWP and SAP will be updated to include dissolved metals monitoring for the following wells downgradient of the injection zone: • Source Area: 01-PZ21A • Intermediate PRB: 01-MW234 • Station Boundary PRB: 02-NEW39 Please note that as stated in Section 6.7.5, continued optimization of monitoring program will be conducted during the course of the operation and maintenance of the remedy. As part of this optimization, the scope of metals monitoring may be revised based on the evaluation of available data. Also see RTC #27 and Comment #28.
27.	Section 6.9: Operating Properly and Successfully (OPS) determination has to take into account the intermediate perchlorate product (chlorate/chlorite) generation/degradation. This needs to be included in the monitoring plan.	All perchlorate reducers completely reduce perchlorate to oxygen and chloride without accumulation of chlorate or chlorite (Bardiya and Bae 2011). Therefore, no monitoring for chlorate/chlorite is required.

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Comments by: *Quang Than, Remedial Project Manager, Brownfields and Environmental Restoration Program, California Department of Toxic Substances Control. Letter dated August 24, 2012*

No.	Comment	Response
28.	Section 7.1: Although the ROD documents that ISB will be the contingency remedy for MNA at Site 2, Section 7.2.3 describes the limitation of degradation of VOCs. Therefore, simply relying on ISB from Site 1 PRB may not be sufficient. Additional measures, e.g., bio-augmentation and enhancement of proper biological activities, may be required, along with proper monitoring, e.g., monitoring for polymer chain reaction (PCR).	Evidence of complete degradation of trichloroethene (TCE) to ethene was observed at IRP Site 2 during the 2009-2010 ISB Pilot Study. Based on this evidence, the biostimulation to be performed during the Site 1 ISB is capable of enhancing VOC degradation, therefore additional measures, e.g., bio-augmentation and PCR monitoring are not anticipated. In addition, the remedy will be routinely optimized based on the monitoring data collected.
29.	Section 7.3/Table 7-3: Rationale for 02-NEW26A (TCE concentrations and extent to the northwest) seems incorrect. Please correct if applicable.	The rationale for 02-NEW26A will be revised as follows: *"Define extent of TCE exceeding its RG to the southeast."*
30.	Section 7.5: Based on Comment #s 17 & 18, it would probably take more than "at least one round of groundwater monitoring" for OPS determination.	The subject statement sets as a minimum, one round of monitoring after the implementation of the remedy before an Operating Properly and Successfully (OPS) Report would be made. FFA signatories will have the opportunity to review and comment on the Draft OPS Report once it is issued. Also please see RTC #s 17 and 18.
31.	Section 8.3.4: It is not clear what/how "discharge of fill material" would occur. Please explain.	The definition of the discharge of fill material per Title 40 of the Code of Federal Regulation (C.F.R.) Section 232.2 includes the building of any structure or infrastructure requiring sand, dirt or other material for its construction. Therefore, installation of wells within the Borrego Canyon Wash may lead to discharge of fill material as defined at 40 C.F.R. Section 232.2. For clarification, the following text will be added at the beginning of Section 8.3.4: *"The definition of the discharge of fill material per 40 C.F.R. Section 232.2 includes the building of any structure or infrastructure requiring sand, dirt or other material for its construction. The implementation of the remedial….."*

Document Title: Draft Remedial Design/Remedial Action Work Plan, Installation Restoration Program Sites 1 and 2 Groundwater, Former Marine Corps Air Station El Toro, California, May 2012

Comments by: *Quang Than, Remedial Project Manager, Brownfields and Environmental Restoration Program, California Department of Toxic Substances Control. Letter dated August 24, 2012*

No.	Comment	Response
32.	Section 8.3.5.2: The second "IRP Site 1 Source Area PRB" appears incorrect. Please correct if applicable.	The subject text will be revised to: *"IRP Site 1 Source Area:* • *10 injection wells* • *5 extraction wells"*
33.	Section 8.3.5.3: This section does not address extraction well installation, which should include proper well size for the type of extraction pump used (submersible pumps as shown on Figure 6-2).	Please note that groundwater extraction will only occur during substrate injection to enhance distribution. Groundwater extraction rates will be on the order of 0.5 gallon per minute (gpm) to 1 gpm for a period not exceeding two weeks. The construction/installation of extraction wells will be the same as the proposed injection wells. The first paragraph of Section 8.3.5.3 will be revised as follows to reflect this: *"All injection**/ extraction** wells will be completed with 2-inch diameter Schedule 80 polyvinyl chloride (PVC) well screen and blank casing. All monitoring wells will be completed with 4-inch diameter Schedule 40 PVC well screen and blank casing. Figure 8-5 presents typical construction details for monitoring and injection**/ extraction** wells."*
34.	Section 8.3.9.1: If VOC is included in the analysis, composite sample will not show the correct VOC concentrations and thus the soil may not be acceptable by the disposal facility.	The third line of Section 8.3.9.1 will be revised to propose collection of discrete samples for volatile organic compound (VOC) analyses if required as follows: *" To obtain representative samples, a composite sample from each rolloff bin will be analyzed for contaminants historically reported in soil at the site. If VOC analysis is required, two discrete samples will be collected from each rolloff bin. The composite sample will be collected as follows……"*

Document Title: Draft Remedial Design/Remedial Action Work Plan, Installation Restoration Program Sites 1 and 2 Groundwater, Former Marine Corps Air Station El Toro, California, May 2012

Comments by: *Quang Than, Remedial Project Manager, Brownfields and Environmental Restoration Program, California Department of Toxic Substances Control. Letter dated August 24, 2012*

No.	Comment	Response
35.	The Sampling and Analysis Plan in Attachment A should be revised accordingly from the comments above, e.g., Decision Rule 6 in Worksheet (WS) #11, Tables in WS #17, etc.	The SAP will be revised in accordance with RTCs #2, #14, #17, #19, and #26 above.
36.	Section 6.3.2.2, Second paragraph under "Source Area and Former Station Boundary Area": The ROI "in excess of 75 feet" appears incorrect. Please correct.	The radius of influence (ROI) referenced in the subject paragraph represent distance up to which influence was observed during the aquifer tests conducted at IRP Site 1. For clarity the second sentence of the subject paragraph will be revised as follows: *"During the aquifer tests conducted within the IRP Site 1 Source Area, the extraction of groundwater at a well within Zone 1 (see Figure 3-3) had an influence on a monitoring well located in excess of 75 feet in the direction transverse to the groundwater flow. Therefore, substrate distribution…."*
37.	Figure 3-5: In the Legend, the concentration units for perchlorate are labeled as mg/L and should probably be µg/L. Please correct.	The subject text in the Legend of Figure 3-5 will be revised to read: "Perchlorate Concentration in Groundwater in micrograms per liter (µg/L) (Date) (J Indicates Estimated Value)."
38.	Page 5-3, Section 5.4.2 [Attachment B]: To be consistent, please insert a bullet before "Property Owned by FAA".	Please see RTC #1, a response to this comment will be provided at a later date.
39.	The convention of naming wells in the WP is not consistent, ranging from 02NEW27A to 02-NEW27A to 02_NEW27A. Please use a consistent convention.	The RD/RAWP will be revised to ensure that correct well identifiers are used consistently throughout the document.

References:

Nirmala Bardiya and Jae-Ho Bae. 2011. Dissimaltory Perchlorate Reduction: A Review. Microbiological Research,May 20;166(4):237-54.

AECOM 2012. Final Work Plan, Supplemental Groundwater Monitoring, Installation Restoration Program Sites 1 and 2, Former Marine Corps Air Station El Toro, California. December.

Document Title: Draft Remedial Design/Remedial Action Work Plan, Installation Restoration Program Sites 1 and 2 Groundwater, Former Marine Corps Air Station El Toro, California, May 2012

Comments by: *Roy L. Herndon, Chief Hydrogeologist, Orange County Water District. Letter dated August 23, 2012*

No.	Comment	Response
1.	The text on p. 3-3 references a document (Trevet, 2012) that reviewed the groundwater elevation data from new wells 02NEW02A, 02NEW07A, 02NEW26A, and 02NEW27A and determined that groundwater flows west-northwest in this vicinity. This is consistent with interpretations by Bechtel in 1997. Figure 3-7 in the Work Plan should show the actual groundwater elevation data for these new wells and interpreted contours rather than simply an arrow. Presumably, these details are contained in the Trevet 2012 report. If possible, I would like to review a copy of the Trevet 2012 report since it apparently provides more detailed information on the four newly installed downgradient wells than what is presented in the Work Plan.	Supplemental groundwater monitoring for Installation Restoration Program (IRP) Sites 1 and 2 was completed in January 2013, and included a comprehensive round of water level gauging for wells within and downgradient of these Sites. Figure 3-7 will be updated based on these data to show groundwater elevation data and interpreted contours. The *"Final Navy Well Reports for Wells 02NEW02A, 02NEW07A, 02NEW26A, and 02NEW27A in Support of the Alton Parkway Extension Project, Installation Restoration Program Site 2, Former Marine Corps Air Station El Toro, California (May 2012)"* was provided to you via email on March 27, 2013.
2.	The Work Plan does not provide any perchlorate or VOC data for the aforementioned four new downgradient wells. Two of these wells (02NEW26A and 02NEW27A were installed in locations not in proximity to previous wells, so water quality data from these new locations could change the current understanding of the perchlorate and VOC plumes. We assume that if these wells had been sampled and analyzed for perchlorate and VOCs, the data would have been presented and incorporated into the Work Plan. In the absence of any water quality data from the four new wells, the interpretations of the downgradient extent of the perchlorate and VOC plumes in this area should be considered preliminary and subject to change.	Data from the Final Navy Well Reports for Wells 02NEW02A, 02NEW07A, 02NEW26A, and 02NEW27A were not available in time to be included in the Draft Remedial Design/Remedial Action Work Plan (RD/RAWP). The Draft Final RD/RAWP will be revised to include perchlorate and VOC data for these 4 new wells.
3.	The text on p. 7-3 refers to a contingency monitoring well 02NEW42 to "refine TCE extent cross-gradient." This characterization of "cross-gradient" is inconsistent with statements on p.3-3 and Figure 3-7 that indicate the location of 02NEW42 would be in a down-gradient direction of the TCE plume. Because the new data from the aforementioned new wells demonstrates the flow direction is west-northwest, it is clear that a downgradient monitoring well is needed in the vicinity of "contingency" monitoring well 02NEW42. Well 02NEW27A, by itself, is too far south to properly monitor the west-northwesterly flow direction of VOCs and	Proposed well 02NEW42 will be installed during the remedial action and included in the well monitoring network. The Draft Final RD/RAWP will be revised in appropriate sections, including Figure 7-1 and Table 7-3, to address this.

Document Title: Draft Remedial Design/Remedial Action Work Plan, Installation Restoration Program Sites 1 and 2 Groundwater, Former Marine Corps Air Station El Toro, California, May 2012

Comments by: *Roy L. Herndon, Chief Hydrogeologist, Orange County Water District. Letter dated August 23, 2012*

No.	Comment	Response
	perchlorate. I had mentioned to DTSC staff previously that this data gap existed after the destruction of 02NEW27, which was optimally located to intercept potential contaminants from Sites 1 and 2. This lack of adequate coverage in the critical downgradient area is now more apparent than ever and justifies the need to construct well 02NEW42 now and incorporate it into the downgradient monitoring program for VOCs and perchlorate. The Work Plan should be modified accordingly, including Figure 7-1 and Table 7-3.	
4.	Table 6-18 shows wells 02NEW07A and 02NEW27A as only being sampled for perchlorate in the first year and no longer thereafter. Given that these wells have apparently never had a single perchlorate analysis performed to date, this proposed sampling schedule for these wells is unjustified. In addition, because these wells, together with well 02NEW26A (which is inexplicably not included in the table), are in a downgradient direction from the perchlorate-impacted groundwater, they should be included as long-term monitoring points to evaluate the performance of the perchlorate remedial actions which include monitored natural attenuation. For the reasons provided in Comment #3 above, "contingency" monitoring well 02NEW42 should be constructed now and also be included as a long-term downgradient monitoring well for annual perchlorate monitoring. Table 6-18 should be modified accordingly.	Table 6-18 will be revised to propose semi-annual groundwater sampling and analysis for perchlorate for wells 02NEW26A and 02NEW42 in Year 1. By the end of Year 1, the Station Boundary Permeable Reactive Barrier (PRB) is expected to be fully operational to treat perchlorate concentrations exceeding the remediation goal. The need for continued groundwater sampling and analysis for perchlorate after Year 1 for wells 02NEW07A, 02NEW26A, 02NEW27A, and 02NEW42 will be evaluated following comprehensive review of PRB performance data and perchlorate distribution data near the Station Boundary. Section 6.7.4 and Table 6-18 of the Work Plan will be updated to reflect this.

Document Title: Draft Remedial Design/Remedial Action Work Plan, Installation Restoration Program Sites 1 and 2 Groundwater, Former Marine Corps Air Station El Toro, California, May 2012

Comments by: *Mary Aycock, Superfund Remedial Project Manager, US Environmental Protection Agency. Email dated August 9, 2012*

No.	Comment	Response
1.	This Remedial Design/Remedial Action Work Plan (RD/RAWP) provides design and implementation procedures for groundwater remedial actions (RAs) at Installation Restoration Program (IRP) Site 1 (former Explosive Ordnance Disposal [EOD] Training Range) and IRP Site 2 (Magazine Road Landfill) at former Marine Corps Air Station (MCAS) El Toro, California, with the guidance of the Comprehensive Environmental Response, Compensation, Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, NCP in Title 40 of the CFR Part 300.	Comment noted.
2.	The investigation of groundwater contamination at IRP Sites 1 and 2 at MCAS El Toro is complete and it is concluded that cleanup is required for perchlorate-impacted groundwater associated with IRP Site 1 and volatile organic compound (VOC)-impacted groundwater associated with IRP Site 2.	Comment noted.
3.	The CERCLA triggered remedial actions that are selected in this document are necessary to protect human health and the environment from actual or threatened releases of hazardous substances into the environment. To accomplish this, remedial design and remedial actions are presented in this RD/RAWP which include in-situ bioremediation (ISB), groundwater monitoring and institutional controls (ICs) for Site 1 and monitored natural attenuation (MNA) and Institutional Controls (ICs) for Site 2.	Comment noted.
4.	The RD/RA Handbook, 9355.0-048, EPA 540/R-95/059, dated June 1995 (RD/RA Handbook) was used to prepare this RD/RAWP. However, Section 4.7.4, Preliminary Design Phase, RD/RA Handbook explains that the preliminary design phase is considered complete when approximately 30 percent of the design work has been completed. Therefore, the information provided within the preliminary design should cover operations and Maintenance (O&M) requirements, preliminary specifications, and O&M costs.	Comment noted. The Remedial Design/Remedial Action Work Plan (RD/RAWP) presents the operation, maintenance and monitoring requirements and specifications. The operation and maintenance costs were presented in the previous Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) documents including groundwater feasibility study and groundwater record of decision.

Document Title: Draft Remedial Design/Remedial Action Work Plan, Installation Restoration Program Sites 1 and 2 Groundwater, Former Marine Corps Air Station El Toro, California, May 2012

Comments by: *Mary Aycock, Superfund Remedial Project Manager, US Environmental Protection Agency. Email dated August 9, 2012*

No.	Comment	Response
5.	In accordance with the EPA guidance for conducting Remedial Investigations and Feasibility Studies Under CERCLA (U.S. EPA 1988b), the technology types included categories of remediation technologies such as ICs, Permeable Reactive Barrier (PRBs), and In-situ bioremediation (ISB).	Comment noted.
6.	EPA Guidance (EPA 1989) will be used to evaluate complete exposure pathways quantitatively to develop the Conceptual Site Model (CSM).	Comment noted.
7.	The Sampling and Analysis Plan (SAP) used the U.S. EPA guidance document "Systematic Planning Using Data Quality Objectives Process, EPA QA/G-4" to apply systematic planning and to generate performance and acceptance criteria in collecting environmental data." Also, "USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review" document was used in the development of sample collection methods and the sampling process sequence of events.	Comment noted.
8.	Relevant information was sourced from several EPA published documents relating to Quality Control, Quality Assurance, Test Methods, Data Quality Assessment, etc. for the preparation of this RD/RAWP.	Comment noted.
9.	EPA prescribed analytical test methods and standard operating procedures (SOPs) are included in the SAP to provide credibility of the test data to be used in the RD/RAWP. It should be noted that the SAP includes a title page for Appendix B (Analytical Laboratory Standard Operating procedures); however, the actual laboratory SOPs are not included in the RD/RAWP.	Comment noted. The laboratory standard operating procedures (SOPs) will be included in the Final RD/RAWP.
10.	Guidance for Evaluation of Federal Agency Demonstration that Remedial Actions are Operating Properly and Successfully (OPS) under CERCLA Section 120 (h)(3) (USEPA 1996) will be used in this RD/RAWP during the determination of OPS for IRP Site 1 groundwater remedy.	Comment noted.

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Comments by: *Mary Aycock, Superfund Remedial Project Manager, US Environmental Protection Agency. Email dated August 9, 2012*

No.	Comment	Response
11.	A U.S. EPA recommended MNA Guidance (USEPA 2004) "Performance Monitoring of MNA Remedies for VOCs in Groundwater, EPA/600/R-04/027, National Risk Management Research Laboratory, April, will be applied to address contingency remedies that may specify technologies that are different from the selected remedy and should be flexible enough to allow for the incorporation of new information about site risks and technologies.	Comment noted.
12.	(U.S. EPA 2006a) Drinking Water Equivalent Level (DWEL) of 24.5 micrograms per liter and the California Maximum Contaminant Level (MCL) of 6 microgram per liter will be used in determining perchlorate level exceedence in groundwater at IRP Site 1 in the Northern EOD Range.	Comment noted.
13.	Assessment Guidance for Perchlorate, the memorandum from Susan Parker Bodine, Assistant Administrator, Washington, D.C. January 26, 2006 (USEPA 2006), recommends a reference dose (RfD) for perchlorate of 0.0007 milligram/kilogram-day (mg/kg-day). This EPA Integrated Risk Information System (IRIS) perchlorate RfD will be used in determining perchlorate level exceedence in groundwater at IRP Site 1 in the Northern EOD range.	Comment noted.

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Comments by: *John Broderick, Land Disposal and DoD Section, Santa Ana Regional Water Quality Control Board. Letter dated July 3, 2012*

No.	Comment	Response
1.	Site 1 – general comment: The plan is basically to inject substrate into the groundwater to stimulate bioremediation by providing a food source to microorganisms to break down the perchlorate to chlorine and oxygen. You have completed, at a minimum, complex feasibility studies, aquifer testing, in situ piloted testing, and microcosm study to determine the effectiveness of the proposed remedy. However, the proposed monitoring frequency for the groundwater monitoring network is semi-annually, with optimization planned for every sampling event to reduce monitoring. We believe that the selected groundwater monitoring frequency is inadequate to demonstrate success or failure of this remedy in order to achieve our agreement for closure.	Quarterly monitoring is proposed during Year 1 for the in-situ bioremediation (ISB) systems installed for remediation of Installation Restoration Program (IRP) Site 1 perchlorate-impacted groundwater (Source Area, Source Area Permeable Reactive Barrier [PRB], Intermediate Area PRB, and Station Boundary PRB) (see Tables 6-13 through 6-16 of the Work Plan). This will be followed by semi-annual monitoring of ISB systems for Years 2 and 3. In addition to ISB monitoring, semi-annual monitoring is proposed for overall perchlorate distribution monitoring as shown in Table 6-18. A total of approximately 75 wells are proposed to evaluate the performance of IRP Site 1 remedy (Tables 6-13 through 6-18). Therefore, the proposed monitoring plan is adequate to evaluate remedy effectiveness. Although, optimization of monitoring network/schedule will be conducted at regular intervals, the purpose of optimization will not be necessarily to reduce monitoring. Additional analytes/ locations may be added to the monitoring/network schedule if the data evaluation necessitates such change in the monitoring program. One such scenario is discussed in Section 6.7.5 (see first bullet item on Page 6-15 that indicates that additional monitoring for pH and alkalinity may be needed if buffers were injected).
2.	Site 2 – general comment: The selected remedy is for monitoring reduction of the contaminants of concern, volatile organic compounds, by monitoring natural reduction through dispersion or other processes. Again, what you are proposing is half of the monitoring normally accepted by our region for this remedy, therefore, we believe the groundwater monitoring frequency is insufficient for the Site 2 selected remedy.	Ten years of historical groundwater monitoring data for IRP Site 2 groundwater has shown that the volatile organic compound (VOC) plume is stable. Also, please note that there are a total of 17 wells being monitored to assess the distribution and attenuation of VOCs. Eleven (11) wells are proposed for semi-annual monitoring as part of IRP Site 2 remedy (Table 7-3), and six (6) additional IRP

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Comments by: *John Broderick, Land Disposal and DoD Section, Santa Ana Regional Water Quality Control Board. Letter dated July 3, 2012*

No.	Comment	Response
		Site 2 wells will also be monitored periodically as part of IRP Site 1 remedy (i.e. Station Boundary PRB) (see Table 6-16). The monitoring frequency for these six wells will be quarterly for Year 1 and semi-annually for Years 2 and 3. Therefore, given the historical dataset and stable nature of the plume, the monitoring frequency for the first three years described above is adequate for evaluating the performance of the groundwater remedy.

Attachment:

Table 6-12: Baseline Groundwater Monitoring Plan – IRP Site 1 Groundwater

Table 6-12: Baseline Groundwater Monitoring Plan – IRP Site 1 Groundwater

Area	Monitoring Locations	Proposed Analyses											
		Perchlorate	VOCs[a]	DO	ORP	pH	Alkalinity	Anions[b]	Methane	Ethene	Ethane	Bromide	TOC
Source Area	01-EW05	✓		✓	✓	✓	✓	✓	✓			✓	✓
	01-EW07	✓		✓	✓	✓	✓	✓	✓			✓	✓
	01-EW09	✓		✓	✓	✓							
	01-IW05	✓		✓	✓	✓							
	01-IW06	✓		✓	✓	✓							
	01-IW07	✓		✓	✓	✓							
	01-IW09	✓		✓	✓	✓							
	01-IW10	✓		✓	✓	✓							
	01-IW14	✓		✓	✓	✓							
Source Area PRB	01-IW03	✓		✓	✓	✓	✓	✓	✓			✓	✓
	01-IW04	✓		✓	✓	✓							
	01-MW205	✓		✓	✓	✓							
	01-PZ21B	✓		✓	✓	✓							
Between Source Area and Intermediate PRBs	01-DGMW57	✓		✓	✓	✓							
	01-MW207	✓		✓	✓	✓							
	01-MW217	✓		✓	✓	✓							
	01-PZ14	✓		✓	✓	✓							
	18BGMW24	✓		✓	✓	✓							
Intermediate PRB	01-DPT01[c]	✓		✓	✓	✓							
	01-DPT02[c]	✓		✓	✓	✓							
	01-DPT09[c]	✓		✓	✓	✓							
	01-DPT10[c]	✓		✓	✓	✓							
	01-MW233	✓		✓	✓	✓	✓	✓	✓			✓	✓
Between Intermediate and Station Boundary PRBs	02-NEW16	✓		✓	✓	✓							
Station Boundary PRB	02-IW05	✓	✓	✓	✓	✓							
	02-IW08	✓		✓	✓	✓							
	02-NEW38	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes:

[a] VOCs include TCE, PCE, cis-1,2-DCE, 1,2-DCA, 1,1,2-TCA, and VC.

[b] Anions include nitrate and sulfate.

[c] Hydropunch samples

✓ Indicates that sample will be collected and analyzed for the listed analyte.

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Comments by: *Patricia Hannon, PG, Engineering Geologist, California Water Quality Control Board, Santa Ana Region. Email dated October 16, 2013*

No.	Comment	Response
	As we discussed during our conference call on October 10, 2013, the responses to our July 3, 2012 comments on the Draft Remedial Design/Remedial Action Work Plan for Groundwater at IRP Sites 1 and 2 are satisfactory. We also discussed the Water Board's second set of comments submitted on July 3, 2013. I have since narrowed down that list and request the following information:	The Navy appreciates the Regional Water Quality Control Board's comprehensive review and concurrence on the Navy responses to their July 3, 2012 comments. The responses to specific requests for information are provided below.
1.	Material Safety Data Sheets and other product information for any materials (such as specific impurities) to be discharged/injected into the subsurface.	The attached product information and Material Safety Data Sheets for the materials proposed for injection will be added to Appendix D of the Draft Final Remedial Design/ Remedial Action Work Plan (RD/RAWP) for Installation Restoration Program (IRP) Sites 1 and 2.
2.	Information on the possibility of adverse impacts to current or potential designated beneficial uses of the groundwater, and whether the impacts will be localized and short-term.	Results from the Pilot Study indicate that implementing in situ bioremediation (ISB) will create reducing conditions locally within a short distance down-gradient from the treatment zones (AECOM/ECS 2011). The Radii of Influence (ROI) of these injections was estimated to range from approximately 5 to 20 feet. In addition, the amendments are anticipated to remain effective over a period of approximately one year upon completion of injections. Therefore, any potential adverse effects from the ISB injections are expected to be short-term and are not expected to adversely impact potential designated beneficial uses of the groundwater. The text below discussing the localized and short term impacts to groundwater will be added at the end of Section 6.3.3: *"Implementation of the remedial action is not anticipated to adversely impact water quality locally or down-gradient of the site in the long-term. The electron donors injected as part of ISB create reducing conditions in the subsurface. Over the short term, this change may cause formerly insoluble forms of metals to dissolve and become mobile over short distances within the aquifer matrix. Any mobilized metals are expected to be adsorbed, precipitated, and/or immobilized immediately down-*

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Comments by: *Patricia Hannon, PG, Engineering Geologist, California Water Quality Control Board, Santa Ana Region. Email dated October 16, 2013*

No.	Comment	Response
		gradient of the reactive zone when oxidizing conditions are restored. Therefore, these temporary water quality impacts due to ISB are expected to be localized and for a relatively short-duration."
. 3.	A Contingency Plan to be implemented to correct unexpected water quality effects that may cause or threaten to cause a condition of pollution or nuisance, or an adverse impact to beneficial uses of groundwater and/or surface water. The contingency plan shall also contain mitigation and control measures to ensure that in the event of surfacing of waste , all surfaced material is safely contained on-site and additional measures are taken to eliminate further surfacing	ISB will be implemented using the knowledge obtained during the Pilot Study (i.g. amendment injection rates and volumes) to assure that surfacing will not occur (none was observed in the Pilot Study) and to minimize any potential adverse effects to groundwater and/or surface water quality (please also see response to comment 2 above). Contingency measures to be implemented in the unlikely event of spills or surfacing will be added to the Activity Hazard Analyses for Substrate Injection in Appendix B of the Accident Prevention Plan/Site Specific Health and Safety Plan (APP/SSHSP). In summary, if surfacing occurs, injections would cease immediately, the spill would be contained, the affected soil or other byproducts would be placed in drums, and the drums would be disposed appropriately.
4.	Infiltration rate	The following information will be added to Section 3.1: *"Surface water infiltration testing has not been conducted at IRP Sites 1 and 2. Based on poorly graded and silty sands overlying the bedrock at IRP Sites 1 and 2, the infiltration rates are expected to be on the order of 0.1 to 0.8 inches per hour (USDA 2008).*
5.	Background water quality of the aquifer - concentrations of total dissolved solids, major cations (sodium, magnesium, potassium) dissolved metals (arsenic, barium, cadmium, total and hexavalent chromium, copper, lead and selenium), dissolved manganese.	Water quality was monitored as part of performance monitoring for the landfill remedy at IRP Site 2 in up-gradient wells. The results are presented in Appendix F of the Final 2nd Annual Long Term Monitoring Report January 2010 – December 2010 Operation and Maintenance Installation Restoration Program Sites 2 and 17 Former Marine Corps Air Station El Toro, California, (October 2011). These results contain all the requested water quality parameters with the exception of hexavalent chromium. Hexavalent chromium dissolves and mobilizes in groundwater under

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Comments by: *Patricia Hannon, PG, Engineering Geologist, California Water Quality Control Board, Santa Ana Region. Email dated October 16, 2013*

No.	Comment	Response
		oxidizing and alkaline conditions. Under reducing (anaerobic/anoxic) conditions, biological reactions would lead to reduction of hexavalent chromium (if present) to trivalent chromium (SWRCB 2009). Anaerobic bioremediation is one of the treatment technologies for hexavalent chromium (Adeniji 2004). As a result, hexavalent chromium is typically not on the list of analytes for background water quality or routine performance monitoring for in situ bioremediation projects where anaerobic conditions are created. Since implementation of bioremediation for IRP Site 1 groundwater will create *anaerobic/anoxic* conditions in subsurface, sampling for hexavalent chromium will not be performed.

References:

Adeniji, Adebowale (for U.S. Environmental Protection Agency). 2004. Bioremediation of Arsenic, Chromium, Lead, and Mercury. August.
State Water Resources Control Board (SWRCB). 2009. Groundwater Information Sheet, Chromium VI, Revised September 2009.
USDA Natural Resources Conservation Service (USDA). 2008. Soil Quality Indicators. June.
AECOM and Enviro Compliance Solutions, Inc. (AECOM and ECS) 2011. Final Technical Memorandum Pilot Study, Installation Restoration Program Site 1. Marine Corps Air Station, El Toro, California. San Diego, California. April.

Attachment A
Product Information and MSDS Sheets — EDS-ER and High Fructose Corn Syrup

Electron Donor Solution

Section 1: Chemical Product and Company Identification

Product Name: Electron Donor Solution Extended Release
Catalog Codes: EDS-ER
CAS#: 8001-22-7
TSCA: TSCA 8(b) inventory: Soybean oil
HMIS Code: H F R P: 10 0 A
Trade Name and Synonyms: EDS-ER
Chemical Family: Glyceride Oils

Contact Information:
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109 E. 17th Street, Suite #3880
Cheyenne, WY 82001
Ph: 307.638.2822 • info@tersusenv.com
www.tersusenv.com
For emergency assistance, call: 919.638.7892

Section 2: Composition and Information on Ingredients

COMPONANT	CAS #	OSHA TWA	OSHA STEL	ACGIH TWA	ACGIH STEL
Soybean Oil	8001-22-7	---	10 mg/m^3	---	---
Vegetable Oil Derived Fatty Acid Esters	Confidential	---	---	---	---

HAZARDOUS INGREDIENTS: NONE AS DEFINED UNDER THE U.S. OSHA HAZARD COMMUNICATION STANDARD (29 CFR 1910.1200) OR THE CANADIAN HAZARDOUS PRODUCTS. ACT S.C. 1987, C.30 (PART 1).

THE PRECISE COMPOSITION OF THIS PRODUCT IS PROPRIETARY INFORMATION. A MORE COMPLETE DISCLOSURE WILL BE PROVIDED TO A PHYSICIAN IN THE EVENT OF A MEDICAL EMERGENCY.

SARA HAZARD: NONE NOTED (SECTION 311/312) TITLE III SECTION 313 - NOT LISTED
All components of this product are listed on the TSCA registry.

Section 3: Physical/Chemical Characteristics

BOILING RANGE: Not applicable VAPOR DENSITY: Exceeds 1.0

SPECIFIC GRAVITY (H20=1.0): 0.93 VAPOR PRESSURE: Not applicable

PERCENT VOLATILE BY VOLUME: 0% SOLUBILITY IN WATER: Miscible

EVAPORATION RATE: Not applicable
APPEARANCE AND ODOR: A pale yellow, oily liquid - only a faint odor.
WEIGHT PER GALLON: 7.7 lbs. at 60F.

Section 4: Fire and Explosion Data

FLAMMABILITY CLASSIFICATION: Combustible Liquid - Class IIIB.
FLASHPOINT: Greater than 550 F (288 C).
METHOD USED: Tag Closed Cup.
EXTINGUISHING MEDIA: CO2, dry chemical, foam, sand.
SPECIAL FIREFIGHTING PROCEDURES: Avoid use of water as it may spread fire by dispersing oil. Use water to keep fire-exposed containers cool. Water spray may be used to flush spills away from fire.

UNUSUAL FIRE AND EXPLOSION HAZARDS: Rags soaked with any oil or solvent can present a fire hazard and should always be stored in UL Listed or Factory Mutual approved, covered containers. Improperly stored rags can create conditions that lead to oxidation. Oxidation, under certain conditions can lead to spontaneous combustion.

Section 5: Reactivity Data

STABILITY: Generally stable. Spontaneous combustion can occur. See Unusual Fire and Explosion Procedures, Section IV.

CONDITIONS TO AVOID: High surface area exposure to oxygen can result in polymerization and release of heat.

INCOMPATABILITY (MATERIALS TO AVOID): Avoid contact with strong oxidizing agents.

HAZARDOUS DECOMPOSITIONS OR BY-PRODUCTS: Decomposition may produce carbon dioxide and carbon monoxide.

HAZARDOUS POLYMERIZATION: Will not occur.

Section 6: Health Hazard Data

THRESHHOLD LIMIT VALUE: As a liquid - none. As oil mist - 10 mg/m3 total particulate.

INHALATION HEALTH RISKS AND SYMPTOMS OF EXPOSURE: Excessive inhalation of oil mist may affect the respiratory system. Oil mist is classified as a nuisance particulate by ACGIH.

SKIN ABSORPTION HEALTH RISKS AND SYMPTOMS OF EXPOSURE: Not classified as a primary skin irritant or corrosive material. Sensitive individuals may experience dermatitis after long exposure of oil on skin.

HEALTH HAZARDS (ACUTE AND CHRONIC): Acute: none observed by inhalation. Chronic: none reported.

EMERGENCY AND FIRST AID PROCEDURES FOR:

SKIN CONTACT: May be removed from skin by washing with soap and warm water.

EYE CONTACT: Immediately flush eyes with plenty of cool water for at least 15 minutes. Do NOT let victim rub eyes.

INHALATION: Immediately remove exposed individual to fresh air source. If victim has stopped breathing give artificial respiration, get medical attention immediately.

Section 7: Precautions for Safe Handling and Use

ENVIRONMENTAL PRECAUTIONS: Where large spills are possible, a comprehensive spill response plan should be developed and implemented.

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED: Wear appropriate respiratory protection and protective clothing as described in section VIII. Depending on quantity of spill: (a) Small spill - add solid adsorbent, shovel into disposable container and wash the area. Clean area with detergent. (b) Large spill - Squeegee or pump into holding container. Clean area with detergent. In the event of an uncontrolled release of this material, the user should determine if this release is reportable under applicable laws and regulations.

WASTE DISPOSAL METHOD: All recovered material should be packaged, labeled, transported, and disposed or reclaimed in accordance with local, state, and federal regulations and good engineering practices.

Section 8: Control Measures

RESPIRATORY PROTECTION: Not normally needed. A qualified health specialist should evaluate whether there is a need for respiratory protection under specific conditions.

VENTILATION: Handle in the presence of adequate ventilation. Intermittent clean air exchanges recommended, but not required.

PROTECTIVE GLOVES: Not normally needed. However, protective clothing is always recommended when handling chemicals.

EYE PROTECTION: Eye protection is always recommended when handling chemicals. Wear safety glasses meeting the specifications established in ANSI Standard Z87.1.

Section 9: Special Precautions

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE: Store away from flame, fire, and excessive heat.

Section 10: Disposal Considerations

General Information: Do not discharge into drains, watercourses or onto the ground. Discharge, treatment, or disposal may be subject to national, state, or local laws. Empty containers may contain product residues.

Disposal Methods: No specific disposal method required.

Container: Since emptied containers retain product residue, follow label warnings even after container is emptied.

Section 11: Transportation Information

DOT Not regulated.
TDG Not regulated.
IATA Not regulated.
IMDG Not regulated.

Section 12: Other Information

Hazard Ratings

	Health Hazard	Fire Hazard	Instability	Special Hazard
NFPA	1	1	0	NONE

Hazard rating: 0 - Minimal; 1 - Slight; 2 - Moderate; 3 - Serious; 4 - Severe
NFPA Label colored diamond code: Blue - Health; Red - Flammability; Yellow - Instability; White - Special Hazards

	Health Hazard	Flammability	Physical Hazard	Personal Protection
HMIS	1	1	0	--

Hazard rating: 0 - Minimal; 1 - Slight; 2 - Moderate; 3 - Serious; 4 - Severe
HMIS Label colored bar code: Blue - Health; Red - Flammability; Orange - Physical Hazards; White - Special

Section 13: Disclaimer and/or Comments

We suggest that containers be either professionally reconditioned for re-use by certified firms or properly disposed of by certified firms to help reduce the possibility of an accident. Disposal of containers should be in accordance with applicable federal, state and local laws and regulations. "Empty" drums should not be given to individuals.

The conditions of handling, storage, use and disposal of the product are beyond our control and may be beyond our knowledge. For this and other reasons, we do not assume responsibility and expressly disclaim liability for loss, damage or expense arising out of or in any way connected with the handling, storage, use or disposal of the product.

The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no event shall Tersus Environmental be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential or exemplary damages, howsoever arising, even if Tersus Environmental has been advised of the possibility of such damages.

EDS-ER™

Water Mixable Oils for Enhanced Anaerobic Bioremediation

It is time to upgrade your emulsified vegetable oil (EVO) to EDS-ER, the next evolution in enhanced bioremediation. EDS-ER (electron donor solution – extended release) is long lasting water mixable oil, designed to release bio-available hydrogen over a period of 3 to 5 years. EDS-ER with a neutral pH has an expected shelf life in excess of two years. Unlike water-based EVO products, EDS-ER is not affected by freezing temperatures (Freezing Point -4 °F (-20 °C)).

Vegetable oils are hydrophobic and tend not to dissolve in or mix with water. To improve the distribution, some suppliers of electron donors add emulsifiers to the oil and mix the solution with water. The electron donor is packaged as an oil-in-water emulsion containing 25 to 50% water. As these EVO products are commonly sold on a $/lb basis, the buyer is purchasing water. To address sustainability concerns of shipping water to project sites, short shelf life and freeze thaw issues, Tersus Environmental has developed an electron donor family of water mixable oils.

Our Product

EDS-ER (electron donor solution – extended release) by Tersus Environmental is a vegetable oil based water mixable oil that self emulsifies on contact with water. EDS-ER contains no water (reduced shipping costs) and is 100% fermentable. There is no water within the formulation. The cost for shipping the electron donor to the project site may be reduced by as much as 50%. The benefit to you and your client is that we offer a lower cost solution to help you close the site.

Purpose

EDS-ER is a simple, safe, low-cost solution for the bioremediation of halogenated compounds (e.g., PCE, TCE, DCE, VC, TCA, CT, etc.), perchlorate, explosives such as aromatic nitrates, energetic munitions residuals, nitrates, acids, radionuclides, select oxidized heavy metals, and other contaminants.

Configuration

EDS-ER applications are easily configured and tailored to meet site-specific conditions. Configurations include applications in grids, barriers and excavations. Because of its low viscosity, EDS-ER can be applied to the subsurface with direct-push injection, hollow-stem auger, existing wells or re-injection wells.

Benefits

- 100% fermentable – contains no water
- Completely water mixable which minimizes the number of injection points for low permeability structures, reducing overall capital costs
- Easily mixes with water for economical application
- Controlled release of electron donors for up to five years
- Food-grade carbon
- Low total dissolved solids to comply with secondary water quality requirements for amendments with low salt content
- Conforms to EPA's EPP (Environmentally Preferable Purchasing) and USDA biobased criteria
- No operations and maintenance
- Clean, low-cost, non-disruptive application (e.g., direct-push, wells and excavations)
- Green sustainable chemistry, made from renewable crop-based oils
- Low cost transportation when compared to other electron donors
- Long shelf life - shelf life unrefrigerated > 2 years
- Freezing Point -4 °F (-20 °C)

Offers Cost Savings

Our EDS-ER technology has the potential to offer significant cost savings to the groundwater remediation industry. The passive nature of EDS-ER eliminates the large capital and operations/maintenance costs associated with active engineered systems. EDS-ER offers a faster and lower cost alternative to drawn out natural attenuation approach.

Longevity

A single EDS-ER application provides a controlled release of electron donors for periods of up to 3 to 5 years, under optimal conditions.

Field Applications

Because of its low viscosity and longevity, EDS-ER is an ideal substrate for injection using direct-push technology for source area, plume and reactive barrier applications. The low viscosity allows a greater volume of EDS-ER to be applied in a shorter period and increases the substrate delivery radius per point. The result is fewer injection points and overall shorter delivery time requirements per site. EDS-ER is also ideal for injection into the subsurface through injection wells or used in soil mixing and excavation projects.

Product Specifications

- Vegetable oil based, 100% fermentable – contains no water
- Neutral pH when mixed with water
- Shelf Life Unrefrigerated > 2 years

Packaging Options

- 55-gallon poly drums
- 275-gallon IBC containers
- 3,000 - 5,000 gallon tankers

Convergence of Gas inFusion Technology & *In Situ* Remediation Technologies

Adding hydrogen-enriched water can enhance the performance Tersus' EDS-ER and other electron donor substrates. Infusing hydrogen into water with the inVentures HiSOC or gPRO technology can reduce the demand for the carbon-based electron donor by as much as 50%. Simply add the hydrogen-infused water to EDS-ER for dilution, pre-conditioning, recirculation or chase water. Further, you can inject the hydrogen-enriched water with your bioaugmentation cultures.

About Us

What if we always settled for the first technology that came along?
Then we would have never gotten to where we are today.

We Develop & Market Innovative, Sustainable, Green Technologies. Tersus Environmental also provides global sales management and marketing services for inVentures Technologies' complete family of groundwater remediation products based on the worldwide-patented Gas inFusion technology, which allows for supersaturated levels of dissolved gas into liquids.

Innovative Sustainable Green Technologies
Tel: 919.453.5577 • info@tersusenv.com
tersusenv.com

Global Supplier of Gas inFusion Technology
Tel: 647.477.2394 • U.S. Tel: 646.688.4426
iSOCinfo.com • gPROinfo.com

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Rev: 14 February 2013

BATORY FOODS

batoryfoods.com
800.367.6975

MATERIAL SAFETY DATA SHEET
CORN SYRUPS (GLUCOSE SYRUPS) & CORN SYRUP/SUCROSE BLENDS

Section I – Chemical Product and Company Identification

Product Name(s) Corn Syrups (Glucose Syrups) and Sucrose/Corn Syrup Blends
CAS# 8029-43-4
Distributor – Batory Foods
1700 Higgins Rd. Suite 300
Des Plaines, IL 60018
Emergency # -- 800-367-6975

Section II – Composition

Hazardous Components – None
% Comp – Not required
OSHA PEL – N/A
ACGIH TLV – N/A

Section III – Hazard Identification

Route or entry
- Eyes – yes
- Indigestion – yes
- Skin – yes
- Inhalation – yes

Acute Health Hazards – None
Chronic Health Hazards – None
Medical Conditions Generally Aggravated by the Exposure – None

Section IV – First Aid Measures

Eyes – Flush with water
Ingestion – None
Inhalation – Treat symptomatically is breaking is abnormal
Skin – wash with water

Section V – Fire Fighting Measures

Flash Point – N/A
Flammable Limits – N/A
Extinguishing Media – water foam or carbon dioxide
Special Fire Fighting Procedures – N/A
Special Fire & Explosion Hazards – N/A
NFPA Hazard Code – Health = 0
Flammability = 0
Reactivity = 0

MATERIAL SAFETY DATA SHEET
CORN SYRUPS (GLUCOSE SYRUPS) & CORN SYRUP/SUCROSE BLENDS

Section VI – Accidental Release Measures

Spill or Leak Procedures – Wash with warm water and sweep up into DOT approved containers.
Follow state & municipal requirements for non-hazardous waste disposal.
Neutralizing Chemicals – None

Section VII – Exposure Controls/Personal Protection

Respiratory – N/A
Protective Gloves – N/A
Ventilation – N/A
Eye Protection – N/A
Work/Hygiene – Good Housekeeping
Other – N/A

Section VIII – Physical & Chemical Properties

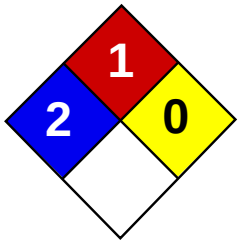
Appearance & Odor – Water white to pale amber liquid; odorless
Boiling Point -- 226°
Specific Gravity – 1.42 @ 100° F
Vapor Density – N/A
Evaporation Rate – N/A
Solubility – 100%
Vapor Pressure – N/A

Section IX – Stability & Reactivity

Stability – Stable
Incompatibility – Not reactive
Conditions to Avoid – N/A
Hazardous Polymerization – Will not occur
Hazardous Decomposition or Byproducts – None

Section X – Toxicological Information

Toxicity Hazard Rating – Not listed under SARA Title III
OSHA – Non-Hazardous



Health	2
Fire	1
Reactivity	0
Personal Protection	E

Material Safety Data Sheet
Cyanocobalamin MSDS

Section 1: Chemical Product and Company Identification

Product Name: Cyanocobalamin

Catalog Codes: SLC5008, SLC2218

CAS#: 68-19-9

RTECS: GL7030000

TSCA: TSCA 8(b) inventory: Cyanocobalamin

CI#: Not available.

Synonym: Vitamin B12; Cobinamide, cyanide phosphate 3'-ester with 5,6-dimethyl-1-alpha-Dribofuranosylbenzimidazole, inner salt

Chemical Formula: C63H88CoN14O14P

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call: 1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Cyanocobalamin	68-19-9	100

Toxicological Data on Ingredients: Cyanocobalamin LD50: Not available. LC50: Not available.

Section 3: Hazards Identification

Potential Acute Health Effects:
Very hazardous in case of ingestion. Hazardous in case of skin contact (irritant), of eye contact (irritant), of inhalation. Slightly hazardous in case of skin contact (permeator).

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. The substance is toxic to lungs, mucous membranes. Repeated or prolonged exposure to the substance can produce target organs damage.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Cold water may be used. Do not use an eye ointment. Seek medical attention.

Skin Contact:
After contact with skin, wash immediately with plenty of water. Gently and thoroughly wash the contaminated skin with running water and non-abrasive soap. Be particularly careful to clean folds, crevices, creases and groin. Cold water may be used. Cover the irritated skin with an emollient. If irritation persists, seek medical attention. Wash contaminated clothing before reusing.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek medical attention.

Inhalation: Allow the victim to rest in a well ventilated area. Seek immediate medical attention.

Serious Inhalation: Not available.

Ingestion:
Do not induce vomiting. Loosen tight clothing such as a collar, tie, belt or waistband. If the victim is not breathing, perform mouth-to-mouth resuscitation. Seek immediate medical attention.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: May be combustible at high temperature.

Auto-Ignition Temperature: Not available.

Flash Points: Not available.

Flammable Limits: Not available.

Products of Combustion: These products are carbon oxides (CO, CO2), nitrogen oxides (NO, NO2...). Some metallic oxides.

Fire Hazards in Presence of Various Substances: Not available.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions:
SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use water spray, fog or foam. Do not use water jet.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

Precautions:
Keep away from heat. Keep away from sources of ignition. Empty containers pose a fire risk, evaporate the residue under a fume hood. Ground all equipment containing material. Do not breathe dust. Wear suitable protective clothing In case of insufficient ventilation, wear suitable respiratory equipment If you feel unwell, seek medical attention and show the label when possible. Avoid contact with skin and eyes

Storage:
Keep container dry. Keep in a cool place. Ground all equipment containing material. Keep container tightly closed. Keep in a cool, well-ventilated place. Combustible materials should be stored away from extreme heat and away from strong oxidizing agents.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection:
Splash goggles. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid.

Odor: Not available.

Taste: Not available.

Molecular Weight: 1355.39 g/mole

Color: Not available.

pH (1% soln/water): Not available.

Boiling Point: Decomposes.

Melting Point: 102.5°C (216.5°F)

Critical Temperature: Not available.

Specific Gravity: Not available.

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water.

Solubility: Partially soluble in cold water.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Not available.

Incompatibility with various substances: Not available.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: Not available.

Polymerization: No.

Section 11: Toxicological Information

Routes of Entry: Eye contact. Inhalation. Ingestion.

Toxicity to Animals:
LD50: Not available. LC50: Not available.

Chronic Effects on Humans: The substance is toxic to lungs, mucous membranes.

Other Toxic Effects on Humans:
Very hazardous in case of ingestion. Hazardous in case of skin contact (irritant), of inhalation. Slightly hazardous in case of skin contact (permeator).

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: Not available.

Special Remarks on other Toxic Effects on Humans: Not available.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The products of degradation are more toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations: TSCA 8(b) inventory: Cyanocobalamin

Other Regulations: OSHA: Hazardous by definition of Hazard Communication Standard (29 CFR 1910.1200).

Other Classifications:

WHMIS (Canada): CLASS D-2A: Material causing other toxic effects (VERY TOXIC).

DSCL (EEC): R36/38- Irritating to eyes and skin.

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 1

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 2

Flammability: 1

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Wear appropriate respirator when ventilation is inadequate. Splash goggles.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

Created: 10/10/2005 08:17 PM

Last Updated: 05/21/2013 12:00 PM

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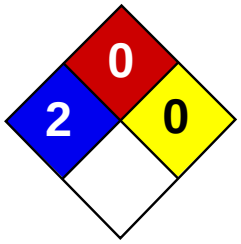

Health	2
Fire	0
Reactivity	0
Personal Protection	E

Material Safety Data Sheet
Sodium bromide MSDS

Section 1: Chemical Product and Company Identification

Product Name: Sodium bromide

Catalog Codes: SLS3820, SLS1600

CAS#: 7647-15-6

RTECS: VZ3150000

TSCA: TSCA 8(b) inventory: Sodium bromide

CI#: Not available.

Synonym: Bromide salt of sodium

Chemical Name: Sodium Bromide

Chemical Formula: NaBr

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call: 1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Sodium bromide	7647-15-6	100

Toxicological Data on Ingredients: Sodium bromide: ORAL (LD50): Acute: 3500 mg/kg [Rat]. 7000 mg/kg [Mouse].

Section 3: Hazards Identification

Potential Acute Health Effects:
Hazardous in case of eye contact (irritant), of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant).

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. Repeated or prolonged exposure is not known to aggravate medical condition.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Cold water may be used. Get medical attention.

Skin Contact:

Wash with soap and water. Cover the irritated skin with an emollient. Get medical attention if irritation develops. Cold water may be used.

Serious Skin Contact: Not available.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Serious Inhalation: Not available.

Ingestion:
Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention if symptoms appear.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Non-flammable.

Auto-Ignition Temperature: Not applicable.

Flash Points: Not applicable.

Flammable Limits: Not applicable.

Products of Combustion: Not available.

Fire Hazards in Presence of Various Substances: Not applicable.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions: Not applicable.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

Precautions:
Do not ingest. Do not breathe dust. Avoid contact with eyes. Wear suitable protective clothing. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Keep away from incompatibles such as oxidizing agents, acids.

Storage: Keep container tightly closed. Keep container in a cool, well-ventilated area. Do not store above 25°C (77°F).

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection:
Splash goggles. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid.

Odor: Not available.

Taste: Not available.

Molecular Weight: 102.91 g/mole

Color: Not available.

pH (1% soln/water): 6.5-8.0

Boiling Point: 1390°C (2534°F)

Melting Point: 755°C (1391°F)

Critical Temperature: Not available.

Specific Gravity: 3.21 (Water = 1)

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water, methanol.

Solubility:
Easily soluble in cold water, hot water. Soluble in methanol. 1 g dissolves in 1.1 ml of water. 1 g dissolves in about 16 ml of alcohol. 1 g dissolves in 6 ml of methanol

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Incompatible materials, moisture

Incompatibility with various substances: Reactive with oxidizing agents, acids.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity:
Absorbs moisture from the air but is not deliquescent. Hygroscopic. Also incompatible with alkaloidal and heavy metal salts, and Bromine Trifluoride.

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Inhalation. Ingestion.

Toxicity to Animals: Acute oral toxicity (LD50): 3500 mg/kg [Rat].

Chronic Effects on Humans: Not available.

Other Toxic Effects on Humans:
Hazardous in case of ingestion, of inhalation. Slightly hazardous in case of skin contact (irritant).

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans:
May cause adverse reproductive effects (male and female effects on fertility and effects on newborns and fetotoxicity) based on animal data Human: passes the placental barrier, detected in maternal milk.

Special Remarks on other Toxic Effects on Humans:
Acute Potential Health Effects: Skin: May cause mild skin irritation. Eyes: Causes eye irritation. Inhalation: May cause respiratory tract irritation. Ingestion: May cause gastrointestinal tract irritation with nausea and vomiting, abdominal pain, constipation. Bromide poisoning following acute ingestion is more rare and may affect the central nervous system (CNS depression - somnolence, confusion, ataxia, coma and other symptoms similar to chronic ingestion), cardiovascular system (hypotension, tachycardia), kidneys (acute renal failure, urinary incontinence), and respiration (acute respiratory distress syndrome). It may also cause eye disturbances such as mydriasis and nystagmus, disturbances of apparent color of objects, blurring or indistinctness of vision, apparent movement or wiggling and change in apparent size of objects, large pupils, subnormal reaction to light, diplopia, and photophobia. Chronic Potential Health Effects: Skin: Prolonged or repeated skin contact may cause skin rashes. Eyes: Prolonged or repeated eye contact may cause blepharitis, and conjunctivitis. Prolonged or repeated ingestion may cause skin rashes (bromoderma, acne, pyoderma gangrenosum, erythema multiforme), affect the liver, endocrine system (thyroid), metabolism(anorexia), blood, vision (visual disturbances, permanently decreased vision and may produce a toxic syndrome, "Bromism" which may be characterized by behavior/central nervous symptoms such CNS depression, irritability, headache, confusion, slurred speech, memory loss, lethargy, ataxia, tremor, agitation, delusion, disoriented, paranoia, aggressiveness, hallucinations, mania, fatigue, seizure, neuropathy, muscle weakness, coma. Also, in individuals with chronic bromism, the tongue may have a coated or furred appearance.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The product itself and its products of degradation are not toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations: TSCA 8(b) inventory: Sodium bromide

Other Regulations: EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC):
R36- Irritating to eyes. S2- Keep out of the reach of children. S24/25- Avoid contact with skin and eyes. S46- If swallowed, seek medical advice immediately and show this container or label.

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 0

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 2

Flammability: 0

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Splash goggles.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

Created: 10/10/2005 08:26 PM

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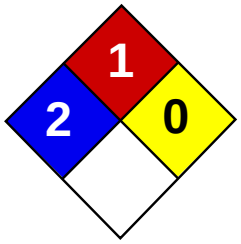

Health	2
Fire	1
Reactivity	0
Personal Protection	E

Material Safety Data Sheet
Fluorescein MSDS

Section 1: Chemical Product and Company Identification

Product Name: Fluorescein

Catalog Codes: SLF1135, SLF1645

CAS#: 2321-07-5

RTECS: LM5075000

TSCA: TSCA 8(b) inventory: Fluorescein

CI#: Not available.

Synonym: CI Solvent Yellow 94; Spiro[isobenzofuran-1(3H),9'-[9H]xanthen]-3-one, 3'6'-dihydroxy-; 2-(6-Hydroxy-3-oxo-(3H)-xanthen-9-yl)benzoic acid; D & C Yellow #7; Fluorescein, alcohol soluble.

Chemical Name: Fluorescein

Chemical Formula: C20H12O5

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call: 1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Fluorescein	2321-07-5	100

Toxicological Data on Ingredients: Fluorescein LD50: Not available. LC50: Not available.

Section 3: Hazards Identification

Potential Acute Health Effects: Hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation.

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Mutagenic for bacteria and/or yeast. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. Repeated or prolonged exposure is not known to aggravate medical condition.

Section 4: First Aid Measures

Eye Contact:

Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention.

Skin Contact:
In case of contact, immediately flush skin with plenty of water. Cover the irritated skin with an emollient. Remove contaminated clothing and shoes. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention.

Serious Skin Contact:
Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek medical attention.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Serious Inhalation: Not available.

Ingestion:
Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. If large quantities of this material are swallowed, call a physician immediately. Loosen tight clothing such as a collar, tie, belt or waistband.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: May be combustible at high temperature.

Auto-Ignition Temperature: Not available.

Flash Points: CLOSED CUP: Higher than 93.3°C (200°F).

Flammable Limits: Not available.

Products of Combustion: These products are carbon oxides (CO, CO2).

Fire Hazards in Presence of Various Substances:
Slightly flammable to flammable in presence of open flames and sparks, of heat. Non-flammable in presence of shocks.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions:
SMALL FIRE: Use DRY chemical powder. LARGE FIRE: Use water spray, fog or foam. Do not use water jet.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

Precautions:

Keep locked up.. Keep away from heat. Keep away from sources of ignition. Empty containers pose a fire risk, evaporate the residue under a fume hood. Ground all equipment containing material. Do not breathe dust. Wear suitable protective clothing. In case of insufficient ventilation, wear suitable respiratory equipment. If you feel unwell, seek medical attention and show the label when possible. Avoid contact with skin and eyes. Keep away from incompatibles such as oxidizing agents.

Storage: Keep container tightly closed. Keep container in a cool, well-ventilated area. Do not store above 24°C (75.2°F).

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection:
Splash goggles. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid. (Solidcrystalline powder.)

Odor: Not available.

Taste: Not available.

Molecular Weight: 332.31 g/mole

Color: Yellow (Yellowish-Red) to Red.

pH (1% soln/water): Not applicable.

Boiling Point: Not available.

Melting Point: 315°C (599°F)

Critical Temperature: Not available.

Specific Gravity: Not available.

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: See solubility in water, methanol, acetone.

Solubility:
Easily soluble in acetone. Soluble in methanol, hot alcohol, glacial acetic acid, alkali hydroxides, and carbonates. Insoluble in cold water, diethyl ether, petroleum ether, benzene.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Excess heat, excess dust generation, incompatible materials

Incompatibility with various substances: Reactive with oxidizing agents.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Inhalation. Ingestion.

Toxicity to Animals:
LD50: Not available. LC50: Not available.

Chronic Effects on Humans: MUTAGENIC EFFECTS: Mutagenic for bacteria and/or yeast.

Other Toxic Effects on Humans: Hazardous in case of skin contact (irritant), of ingestion, of inhalation.

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: Not available.

Special Remarks on other Toxic Effects on Humans:
Acute Potential Health Effects: Skin: May cause skin irritation. Eyes: Causes eye irritation. Ingestion: May cause irritation of the gastrointestinal (digestive) tract. Inhalation: may cause respiratory tract irritation. The toxicological properties of this substance have not been fully investigated.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The product itself and its products of degradation are not toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:
Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations:
TSCA 8(b) inventory: Fluorescein SARA 313 toxic chemical notification and release reporting: Fluorescein

Other Regulations: EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC):
R36/38- Irritating to eyes and skin. S24/25- Avoid contact with skin and eyes. S37- Wear suitable gloves. S45- In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 1

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 2

Flammability: 1

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Splash goggles.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

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Attachment A
Sampling and Analysis Plan

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SAP Worksheet #1: Title and Approval Page

Final
SAMPLING AND ANALYSIS PLAN
03 January 2014

Groundwater Remedial Design/Remedial Action Installation Restoration Program Sites 1 and 2

FORMER MARINE CORPS AIR STATION EL TORO, CALIFORNIA

Prepared for:

Naval Facilities Engineering Command Southwest
Program Management Office West
1455 Frazee Road, Suite 900
San Diego, CA 92108-4310

Prepared by:

AECOM-Envirocon JV
1420 Kettner Blvd, Suite 500
San Diego, CA 92101
(619) 233-1454

Prepared under:
Contract No. N62473-11-D-2231
Contract Task Order 0002

DCN: AEJV-2231-0002-0005

Review Signature: C S Barr — 1/3/14
Christopher S. Barr, CMQ/OE, CQA, QAM, , AECOM-Envirocon JV — **Date**

Approval Signature: Joseph Michalowski — January 21, 2014
Joseph Michalowski, NAVFAC SW QAO — **Date**

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EXECUTIVE SUMMARY

This sampling and analysis plan, which consists of a field sampling plan (FSP) and a quality assurance project plan (QAPP), has been prepared for the groundwater remedial action implementation at the Installation Restoration Program (IRP) Site 1, the Explosive Ordnance Disposal Training Range, and IRP Site 2 the Magazine Road Landfill at former Marine Corps Air Station El Toro, California. The remedial actions for groundwater associated with IRP Sites 1 and 2 are consistent with the final remedies for both sites documented in the Groundwater Record of Decision (DON 2012) finalized in January 2012. The FSP and QAPP delineate technical objectives, data acquisition methods and data assessment procedures for sampling and analyses conducted as a part of the environmental investigations. Additionally, the FSP and QAPP document the quality assurance and quality control activities to be implemented during sampling and analysis.

This document has been prepared for the Base Realignment and Closure, Program Management Office West and the Naval Facilities Engineering Command Southwest under contract task order 0002 of the Performance Based Environmental Multiple Award Contracts, contract number N62473-11-D-2231.

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ACRONYMS AND ABBREVIATIONS

µg/L	micrograms per liter
1,2-DCA	1,2-dichloroethane
1,1,2-TCA	1,1,2-trichloroethane
AECOM	AECOM Technical Services, Inc.
AEJV	AECOM-Envirocon Joint Venture
AL	action limit
API	American Petroleum Institute
BEC	BRAC Environmental Coordinator
bgs	below ground surface
BNI	Bechtel National, Inc.
BRAC	Base Realignment and Closure
CAGN	coastal California gnatcatcher
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
cis-DCE	cis-1,2-dichloroethene
CLP	Contract Laboratory Program
COC	chemical of concern and chain-of-custody
CSM	conceptual site model
CSO	Caretaker Site Office
CSS	coastal sage scrub
CTO	contract task order
CVAA	cold vapor atomic absorption
DI	de-ionized
DL	detection limit
DO	dissolved oxygen
DoD	Department of Defense
DON	Department of the Navy, United States
DQI	data quality indicator
DQO	data quality objective
DTSC	California Department of Toxic Substances Control
ECS	Enviro Compliance Solutions, Inc.
EMAX	EMAX Laboratories, Inc.
EOD	explosive ordnance disposal
EPA	Environmental Protection Agency, United States
ESS	explosives safety submission
EVO	emulsified vegetable oil
EWI	Environmental Work Instruction
FBI	Federal Bureau of Investigation

FCR	field change request
FFA	Federal Facility Agreement
FS Smoke	chorosuffonic acid
FSP	field sampling plan
GMP	Groundwater Monitoring Program
HSA	hollow-stem auger
IC	institutional control
ICP	inductively coupled plasma
ID	identification
IDQTF	Intergovernmental Data Quality Task Force
IRP	Installation Restoration Program
ISB	in situ bioremediation
KO	contracting officer
LCS	laboratory control sample
LDC	Laboratory Data Consultants
LOD	limit of detection
LOQ	limit of quantification
LQAP	Laboratory Quality Assurance Program
MBTA	Migratory Bird Treaty Act
MCAS	Marine Corps Air Station
MCL	maximum contaminant limit
MCLG	maximum contaminant limit goal
mg/L	milligram per liter
MNA	monitored natural attenuation
MPPEH	material potentially presenting an explosive hazard
MS	matrix spike
MSD	matrix spike duplicate
msl	mean sea level
mV	milliVolts
NAVFAC SW	Naval Facilities Engineering Command Southwest
NEESA	Naval Energy and Environmental Support Activity
ORP	oxidation-reduction potential
PARCCS	precision, accuracy, representativeness, completeness, comparability, and sensitivity
pH	negative log of the hydrogen ion concentration
PMO	Program Management Office
POC	point-of-contact
PQL	project quantitation limit
PRB	permeable reactive barrier
PVC	polyvinyl chloride

RAO	remedial action objective
O&M	operation and maintenance
QA	quality assurance
QAO	Quality Assurance Officer
QAPP	quality assurance project plan
QC	quality control
QL	quantitation limit
QSM	quality system manual
RA	remedial action
RG	remediation goal
RD	remedial design
ROD	Record of Decision
RPD	relative percent difference
RPM	remedial project manager
RWQCB	California Regional Water Quality Control Board
SAP	Sampling and Analysis Plan
SOP	standard operating procedure
SSHO	Site Safety and Health Officer
TCE	trichloroethylene
TOC	total organic carbon
UFP-QAPP	Uniform Federal Policy for Quality Assurance Project Plans
U.S.	United States
USFWS	United States Fish and Wildlife Service
UXO	unexploded ordnance
VC	vinyl chloride
VOC	volatile organic compound
WP	work plan

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SAP Worksheet #2: Sampling and Analysis Plan Identifying Information

Site Name/Number:	**Former Marine Corps Air Station (MCAS), El Toro, California, Installation Restoration Program (IRP) Sites 1 and 2**
Operable Unit:	**n/a**
Contractor Name:	**AECOM – Envirocon Joint Venture (AEJV)**
Contract Number:	**N62473-11-D-2231**
Contract Title:	**Performance Based Multiple Award Contract**
Work Assignment Number (optional):	**Contract Task Order (CTO) 0002**

1. This sampling and analysis plan (SAP) was prepared in accordance with the requirements of the *Uniform Federal Policy for Quality Assurance Plans (UFP-QAPP)* (IDQTF 2005a & 2005b) and United States (U.S.) Environmental Protection Agency (EPA) *Guidance for Quality Assurance Project Plans, EPA QA/G-5* (EPA 2002). In addition, the following guidances were used to prepare the SAP:

- NAVFAC SW Environmental Work Instructions (EWIs)
  - EWI#1 – Chemical Data Validation (28 November 2001)
  - EWI#2 – Review, Approval, Revision and Amendment of Sampling and Analysis Plans (SAPs) (12 January 2011)
  - EWI#3 – Laboratory Quality Assurance Program (LQAP) (23 August 2010)
  - EWI#4 – Implementing and Maintaining the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Administrative Record and Compendium at Southwest Division (May 2007)
  - EWI#6 – Environmental Data Management and Required Electronic Delivery Standards (19 April 2005)
- Department of Defense Quality Systems Manual (DoD 2010)
- Guidance for the Data Quality Objectives Process, U.S. EPA QA/G-4 (EPA 2006)

2. Regulatory program: The remedial action implementation at IRP Sites 1 and 2 and associated sampling and analysis, will be conducted under the CERCLA.
3. This SAP is Project Specific.
4. List organizational partners (stakeholders) and identify the connection with lead organization:

Organization Partners/Stakeholders	Connection	Date
U.S. EPA	EPA is a regulatory partner	
California Department of Toxic Substances Control (DTSC)	DTSC is a regulatory partner	
California Regional Water Quality Control Board (RWQCB), Santa Ana Region	RWQCB is a regulatory partner	

5. Lead Organization: Naval Facilities Engineering Command, Southwest (NAVFAC SW)

6. If any required SAP elements or required information are not applicable to the project or are provided elsewhere, then note the omitted SAP elements and provide an explanation for their exclusion below:

   - No Special Personnel Training is required for this project (WS#8).

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33	QA Management Reports Table	Page 121
D. Data Review		
34-36	Data Verification and Validation (Steps I and IIa/IIb) Process Table	Page 123
37	Usability Assessment	Page 127

Notes:
QA quality assurance
SAP Sampling and Analysis Plan
SOP Standard Operating Procedure
UFP-QAPP Uniform Federal Policy for Quality Assurance Project Plans

SAP Worksheet #3: Distribution List

SAP Recipients	Title	Organization	Telephone Number (optional)	E-mail Address or Mailing Address
Navy				
Content Arnold	Lead Remedial Project Manager (RPM)	BRAC PMO West	(619) 532-0790	content.arnold@navy.mil
Morgan Rogers	RPM	BRAC PMO West	(619) 532-0930	morgan.rogers.ctr@navy.mil
James Sullivan	BRAC Environmental Coordinator (BEC)	BRAC PMO West	(619) 532-0966	james.b.sullivan2@navy.mil
Joseph Michalowski	Quality Assurance Officer (QAO)	NAVFAC Southwest	(619) 532-4125	joseph.michalowski@navy.mil
Diane Silva	Administrative Records Manager	NAVFAC SW	(619) 556-1280	diane.silva@navy.mil
Scott Kehe	Southwest Division Field Safety Navy Technical Representative (NTR)	NAVFAC Southwest	(562) 572-5876	scott.kehe@navy.mil
Regulatory Agencies				
Patricia Hannon	RPM	RWQCB, Santa Ana Region	(951) 782-4498	patrica.hannon@waterboards.ca.gov
Mary Aycock	RPM	U.S. EPA	(415) 972-3289	aycock.mary@epamail.epa.gov
Eileen Mananian	RPM	DTSC	(714) 484-5349	eileen.mananian@dtsc.ca.gov
Remedial Design/Action Contractor				
Steven Tsai	Remedial Design/Remedial Action Implementation Program Manager	AEJV	(619) 233-1454	steve.tsai@aecom.com
Crispin Wanyoike	Remedial Design/Remedial Action Implementation Project Manager	AEJV	(714) 689-7286	crispin.wanyoike@aecom.com
Chris Barr	Program Quality Control Manager	AEJV	(858) 300-2700	chris.barr@aecom.com

SAP Recipients	Title	Organization	Telephone Number (optional)	E-mail Address or Mailing Address
Gaurav Dhody	Project Quality Control Manager	AEJV	(714) 689-7266	gaurav.dhody@aecom.com
Harvinder Singh	Project Engineer	AEJV	(713) 267-3227	harvinder.singh@aecom.com
Joe Ocken	Program Health and Safety Manager	AEJV	(406) 523-1194	jocken@envirocon.com
Chris Cavers	Site Safety and Health Officer (SSHO)	AEJV	(714) 689-7193	chris.cavers@aecom.com
Philip Granger	Field Manager	AEJV	(714) 689-7207	philip.granger@aecom.com
Leta Maclean	Project Chemist	AEJV	(858) 300-2703	leta.maclean@aecom.com
Ye Myint	Analytical Laboratory Project Manager	EMAX	(310) 618-8889	ymyint@emaxlabs.com
Stella Cuenco	Data Validation Project Manager	LDC	(760) 634-0437	scuenco@lab-data.com

Notes:

AEJV	AECOM-Envirocon Joint Venture
BRAC	BRAC Environmental Coordinator
BRAC	Base Realignment and Closure
DTSC	California Department of Toxic Substances Control
EMAX	EMAX Laboratories, Inc.
EPA	Environmental Protection Agency
LDC	Laboratory Data Consultants
NAVFAC SW	Naval Facilities Engineering Command Southwest
NTR	Navy Technical Representative
PMO	Project Management Officer
QAO	Quality Assurance Officer
RPM	Remedial Project Manager
RWQCB	California Regional Quality Control Board, Santa Ana Region
SAP	Sampling and Analysis Plan
SSHO	Site Safety and Health Officer
U.S.	United States

SAP Worksheet #4: Project Personnel Sign-Off Sheet

The undersigned acknowledge receipt and will implement the plan and requirements of this Sampling and Analysis Plan.

Name	Organization/Title/Role	Telephone Number (optional)	Signature/email receipt	SAP Worksheet Reviewed	Date SAP Read
Crispin Wanyoike	AEJV / RD/RA Implementation Project Manager	(714) 689-7286			
Harvinder Singh	AEJV / Project Engineer	(713) 267-3227			
Leta Maclean	AEJV / Project Chemist	(858) 300-2703			
Chris Cavers	AEJV/ Site Safety & Health Officer (SSHO)	(714) 689-7193			
Philip Granger	AEJV / Site Superintendent/Field Manager	(714) 689-7207			
Ye Myint	EMAX/ Analytical Laboratory Project Manager	(310) 618-8889			
Stella Cuenco	LDC / Data Validation Project Manager	(760) 634-0437			

Notes:

AEJV	AECOM-Envirocon Joint Venture
EMAX	EMAX Laboratories, Inc.
LDC	Laboratory Data Consultants
RA	Remedial Action
RD	Remedial Design
SAP	Sampling and Analysis Plan
SSHO	Site Safety and Health Officer

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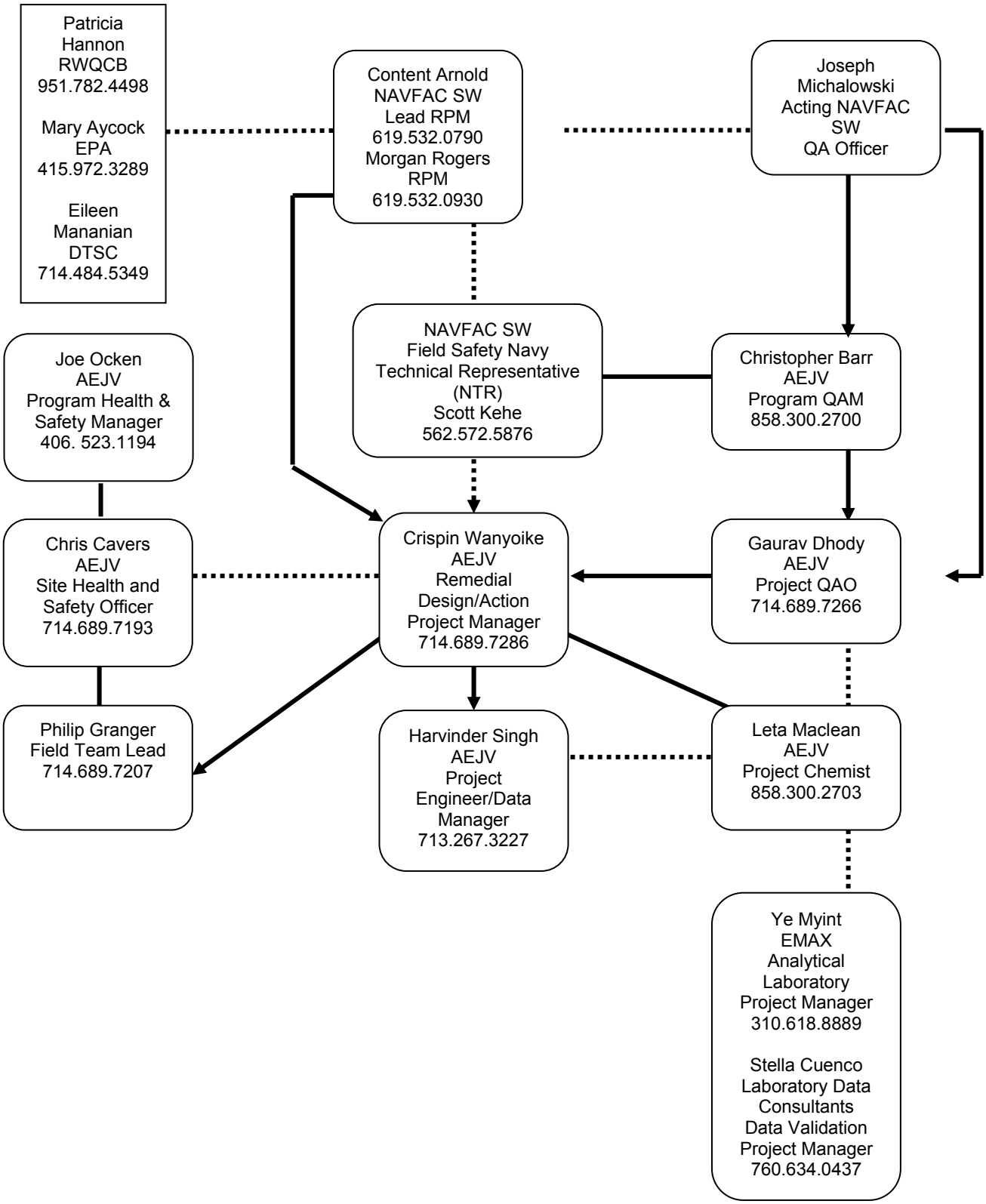
Project Organizational Chart

Lines of Authority ——— Lines of Communication



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SAP Worksheet #6: Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)
Navy POC for technical execution	NAVFAC SW Lead RPM	Content Arnold	(619) 532-0790	RPM and/or Lead RPM will provide technical direction for all aspects of the project.
Navy POC for technical execution	NAVFAC SW RPM	Morgan Rogers	(619) 532-0930	
POC for DON quality issues	NAVFAC SW QAO	Joseph Michalowski	(619) 532-4125	QAO will review and approve this SAP and all amendments to this SAP.
Point of contact to coordinate base activities	Southwest Division Field Safety NTR	Scott Kehe	(562) 572-5876	The Southwest Division Field Safety NTR will coordinate construction activities for the base.
Project management	AEJV Remedial Design/Remedial Action Contractor Project Manager	Crispin Wanyoike	(714) 689-7286	Project Manager will manage the contract, deliverables, and project personnel.
Field team leader	AEJV	Philip Granger	(714) 689-7207	Supervise field activities. Communicate daily activities to Project Chemist and Program Quality Control Manager.
Program Quality Control Manager	AEJV Program Quality Manager	Chris Barr	(858) 300-2700	Oversee project quality, ensuring that quality assurance activities are performed in accordance with project and Navy requirements. The Program Quality Control Manager will communicate the status of quality activities to the Navy Quality Assurance Officer (QAO) by phone or by email.
Technical oversight	AEJV Project Engineer	Harvinder Singh	(713) 267-3227	Communication of relevant technical information to the project manager and field team.
Coordination and communication of fieldwork activities related to sampling	AEJV Site Superintendent	Philip Granger	(714) 689-7207	The Site Superintendent will communicate relevant field information to the Project Manager and Project Chemist.
Coordination of laboratory for field activities and data validation	AEJV Project Chemist	Leta Maclean	(858) 300-2703	Project Chemist will contact the laboratory to provide all necessary sample containers and appropriate shipping materials (such as coolers and bubble wrap) to be delivered on site before field sampling begins and throughout the project.
Submittal of samples to the laboratory	AEJV Sampling Personnel	Philip Granger	(714) 689-7207	Sampling personnel will package and ship samples in accordance with this SAP.

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)
Daily chain-of-custody reports and shipping documentation	AEJV Sampling Personnel	Philip Granger	(714) 689-7207	Chain of custodies and shipping documentation will be submitted via fax or e-mail to the Project Chemist at the end of each day that samples are collected.
Reporting laboratory data quality issues	EMAX Analytical Laboratory Project Manager	Ye Myint	(310) 618-8889	All QA/QC issues will be reported by the laboratory Project Manager to the Project Chemist in writing within 2 business days.
Field and analytical corrective actions	AEJV Project Chemist	Leta Maclean	(858) 300-2703	The Project Chemist will immediately notify the Project Quality Manager and Program Quality Manager in writing of any field or analytical procedures that were not performed in accordance with this SAP. The project chemist, in coordination with the Project Quality Manager, will complete documentation of the non-conformance and corrective actions to be taken. The Project Chemist will verify that the corrective actions have been implemented.
Release of analytical data	AEJV Project Chemist	Leta Maclean	(858) 300-2703	The Project Chemist will review faxed/e-mailed data to verify that data quality is met as described in this SAP before the data are released. Analytical data will be released to the Project Manager (or designee) after the Project Chemist has verified that the data are in accordance with the SAP requirements.
Notification of non-usable analytical data	AEJV Project Chemist	Leta Maclean	(858) 300-2703	If significant problems are identified by the laboratory or the project team that impact the usability of the data (i.e., the data are rejected or the data quality objectives are not met), the Quality Manager or Project Chemist will notify the NAVFAC SW RPM and the NAVFAC SW QAO within 24 hours or the next business day.
Stop Work Issues	Navy RPM NAVFAC SW QAO	Morgan Rogers Joseph Michalowski	(619) 532-0930 (619) 532-4125	The RD/RA Project Manager will notify the Navy RPM and the Navy QAO via e-mail within 24 hrs if there is any work-stoppage due to QA/QC issues. A corrective action report will be submitted via e-mail within 24 hrs. If significant corrective actions occur as determined by the Navy RPM, a corrective action report will be submitted to the regulatory agencies via e-mail within 1 week.
SAP procedure revision during field activities	AEJV Project Chemist	Leta Maclean	(858) 300-2703	The Project Chemist will prepare a field change request for any changes in sampling procedures that occur as a result of conditions in the field. This request will be submitted to the Project Quality Manager and Program Quality Manager for approval prior to initiation of the change.

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)
SAP amendments	AEJV Project Quality Manager	Gaurav Dhody	(714)-689-7266	Any changes to the SAP will require the Project Quality Manager to prepare an addendum that will be approved by the NAVFAC SW QAO before any field activities begin.

Notes:

AEJV	AECOM-Envirocon Joint Venture
COC	chain-of-custody
DON	Department of the Navy
EMAX	EMAX Laboratories, Inc.
NAVFAC SW	Naval Facilities Engineering Command Southwest
NTR	Navy Technical Representative
QA	quality assurance
QAO	quality assurance officer
QC	quality control
POC	point-of-contact
RPM	remedial project manager
SAP	Sampling and Analysis Plan

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SAP Worksheet #7: Personnel Responsibilities Table

Name	Title/Role	Organizational Affiliation	Responsibilities	Education and/or Experience Qualifications (Optional)
Mary Aycock	U.S. EPA RPM	U.S. EPA	These agency RPMs are responsible for overseeing and monitoring the progress of the RD/RA implementation and conformance of these activities with the requirements of the Federal Facility Agreement.	
Eileen Mananian	DTSC RPM	DTSC		
Patrica Hannon	RWQCB Santa Ana Region RPM	RWQCB		
Content Arnold	Navy Lead RPM	BRAC PMO West	The RPM is responsible for all CERCLA-related activities that take place at IRP Sites 1 and 2. Specific tasks include reviewing recommendations made by the RD/RA contractor, reviewing proposed changes to the engineering design, and overseeing the overall implementation of the remediation.	
Morgan Rogers	Navy RPM	BRAC PMO West	The RPM supports the Lead RPM in reviewing recommendations made by the contractor, reviewing proposed changes to the remediation approach, and overseeing the overall implementation of the remedial action; performing project management for the DON; ensuring that the project scope of work requirements are fulfilled; overseeing the project cost and schedule; and acting as lead interface with agencies.	
Scott Kehe	Southwest Division Field Safety Navy Technical Representative	NAVFAC SW	The Southwest Division Field Safety NTR is responsible for coordination of all the work that takes place at former MCAS El Toro. Specific tasks include reviewing vendor submittals and personnel qualifications, conducting constructability reviews, and overseeing construction.	
Joseph Michalowski	Navy QAO	NAVFAC SW	The QA Officer is responsible for government oversight of the QA program and provides quality-related direction for the project. The QA Officer has the authority to suspend project or site activities if NAVFAC SW-approved quality requirements are not adequately followed.	
James Sullivan	BRAC Environmental Coordinator	BRAC PMO West	The BRAC Environmental Coordinator (BEC) chairs the BCT and is responsible for coordinating environmental restoration and compliance programs and updating the BRAC Cleanup Plan at former MCAS El Toro.	
Mark Muralt	Navy Contracting Officer	BRAC PMO West	The contracting officer (KO) is responsible for the negotiation and execution of the construction contract. The KO is responsible for providing technical direction to the construction contractor.	

Name	Title/Role	Organizational Affiliation	Responsibilities	Education and/or Experience Qualifications (Optional)
Crispin Wanyoike	Remedial Design/Remedial Action Contractor Project Manager	AEJV	The Project Manager has overall responsibility for all work performed for the RD/RA implementation. Responsibilities include project planning, scheduling, staffing, executing tasks and subcontracts, and managing deliverables.	
Chris Barr	Contractor Program Quality Manager	AEJV	The Quality Manager is responsible for developing the QA process and supervising audits of the project for compliance with the project-specific procedures and requirements provided in the contract, RD/RA work plan, and statements of work developed by the RD/RA contractor. The Quality Manager will be independent of the cost, scheduling, and other performance constraints that are the responsibility of the Project Manager.	
Joe Ocken	Health and Safety Manager	AEJV	The Health and Safety Manager is responsible for developing and implementing the program health and safety plan and project-specific modifications and amendments.	
Charles Singley	Contracts/ Procurement Manager	AEJV	The Contracts Manager is responsible for soliciting, selecting, and managing subcontracts for remedial action construction services and materials required for the project.	
Chris Cavers	Site Safety and Health Officer	AEJV	The project Site Safety and Health Officer (SSHO) is responsible for conducting periodic safety reviews of the project site, performing regular and frequent site inspections to identify hazards, conducting tailgate safety meetings in conjunction with Site Superintendent and maintaining attendance logs and records, and recording and documenting safety incidents on site.	
Leta Maclean	Project Chemist	AEJV	The Project Chemist is responsible for ensuring that the field sampling and laboratory analyses are performed in accordance with laboratory and field sampling procedures identified in this SAP.	
Gaurav Dhody	Project QC Engineer	AEJV	The Project QC Engineer is responsible for ensuring that subcontractors and vendors comply with project requirements and contractual obligations, and that all field activities are performed as required by the project design. The QC Engineer is a qualified and trained person who reports to the Quality Manager on quality matters.	
Harvinder Singh	Project Engineer	AEJV	The Project Engineer assists the Site Superintendent and the Program Manager by reviewing engineering design documents and interfacing with engineering design personnel and field operations personnel to communicate job requirements.	

Name	Title/Role	Organizational Affiliation	Responsibilities	Education and/or Experience Qualifications (Optional)
Philip Granger	Site Superintendent	AEJV	The Site Superintendent is responsible for the day-to-day supervision of staff and coordination of tasks for project completion. This includes review of engineering design documents, planning and oversight of field activities, and QC.	

Notes:

AEJV	AECOM-Envirocon Joint Venture
BCT	BRAC Cleanup Team
BEC	BRAC Environmental Coordinator
BRAC	Base Realignment and Closure
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DTSC	California Department of Toxic Substances Control
EMAX	EMAX Laboratories, Inc.
EPA	Environmental Protection Agency
IRP	Installation Restoration Program
KO	Contracting Officer
LDC	Laboratory Data Consultants
MCAS	Marine Corps Air Station
NAVFAC SW	Naval Facilities Engineering Command Southwest
NTR	Navy Technical Representative
PMO	Project Management Officer
QA	quality assurance
QAO	Quality Assurance Officer
QC	quality control
RA	Remedial Action
RD	Remedial Design
RPM	Remedial Project Manager
RWQCB	California Regional Quality Control Board, Santa Ana Region
SAP	Sampling and Analysis Plan
SSHO	Site Safety and Health Officer
SSO	Site Safety Officer
U.S.	United States

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SAP Worksheet #8: Special Personnel Training Requirements Table

Project Function*	Specialized Training By Title or Description of Course	Training Provider	Training Date	Personnel / Groups Receiving Training	Personnel Titles / Organizational Affiliation	Location of Training Records / Certificates
None						

Note: No Special Personnel Training is required for this project. All field personnel have been trained in sampling procedures and hold current Occupational Safety and Health Administration 40-hour Hazardous Waste Operations and Emergency Response Training. The field team leader will act as the site safety and health officer, and has 30-hour construction safety training as specified by EM-385-1-1.

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SAP Worksheet #9: Project Scoping Session Participants Sheet

Review and concurrence with this planning document comprises the balance of the project scoping process.

Project Name: Remedial Design/Remedial Action, IRP Sites 1 and 2
Projected Date(s) of Sampling:
Project Manager: Crispin Wanyoike (AEJV)
Site Name: IRP Sites 1 and 2
Site Location: Former MCAS El Toro, California

Date of Session: 27 October 2011
Scoping Session Purpose: Kick-Off Meeting for Remedial Design/Remedial Action Implementation

Name	Title	Affiliation	Phone #	E-mail Address	Project Role
James Callian	BRAC Environmental Coordinator (BEC)	BRAC PMO West	(619) 532-0932	james.callian@navy.mil	
Content Arnold	Navy Lead RPM	BRAC PMO West	(619) 532-0790	content.arnold@navy.mil	
Louie Cardinale	Navy RPM	BRAC PMO West	(619) 532-0979	rene.cardinale@navy.mil	
Mark Muralt	Contract Specialist	BRAC PMO West	(619) 532-0779	Mark.muralt@navy.mil	
Crispin Wanyoike	Project Manager	AEJV	(714) 689-7286	crispin.wanyoike@aecom.com	
Eric Peterson	AECOM Operations Manager	AEJV	(714) 689-7291	eric.peterson@aecom.com	
Harvinder Singh	Project Engineer	AEJV	(713) 267-3227	harvinder.singh@aecom.com	

Notes:
AEJV AECOM-Envirocon Joint Venture
BEC BRAC Environmental Coordinator
BRAC Base Realignment and Closure
PMO Project Management Office
RPM Remedial Project Manager

The following are major issues and decisions concerning IRP Sites 1 and 2:

IRP Sites 1 and 2 Comments/Decisions:

- Mr. Wanyoike provided an overview of the meeting agenda, objectives, and key project team members. Mr. Wanyoike also pointed out that a sheet with contact information of key project team members is attached to the agenda provided to the Navy Team members.

- Mr. Singh provided an overview of the technical approach for the project. The figure and table presenting the technical approach schematics and attached to agenda were used as references.

- Mr. Wanyoike indicated that AEJV will need to perform a comprehensive round of groundwater sampling that will be used a baseline for preparing the Remedial Design (RD)/Remedial Action (RA) Work Plan (WP). He also indicated that AEJV's proposal to the Navy stated that this sampling will be conducted per the methods and procedures for the Groundwater Monitoring Program (GMP) for Anomaly Area 3, and Site 1 and 2, which have already been approved by the regulatory agencies.

- Mr. Wanyoike indicated that AEJV understands that the baseline sampling will be conducted for off-Station wells after they are replaced as part of construction of Alton Parkway.

- Ms. Arnold indicated that natural resources coordination with U.S. Fish and Wildlife Service for the project should be consistent with the coordination conducted during the recently completed time-critical removal action for Site 1. The details required for natural resources coordination will need to be incorporated into the RD/RA Work Plan and presented to the pertinent agencies.

Action Items:

- The Navy Team will provide coordination for comprehensive pre-design groundwater sampling to be conducted in conjunction with the current GMP for Anomaly Area 3, and Site 1 and 2.

Consensus Decisions: Technical recommendations are accepted, pending review of the RD/RA Work Plan.

SAP Worksheet #10: Conceptual Site Model

This section presents historical background information and the Conceptual Site Model (CSM) for IRP Sites 1 and 2, including activities that may have led to release of constituents of concern. This information is presented in detail in Sections 2 and 3, respectively of the WP. In addition, the Work Plan presents a history of environmental investigations conducted at IRP Site 1 and 2. A summary of the nature and extent of constituents of concern at IRP Sites 1 and 2 is presented in detail in Section 3.1.3 of the WP.

10.1 IRP SITE 1 LOCATION AND BACKGROUND

IRP Site 1 is situated within a tributary canyon of Borrego Canyon Wash at elevations ranging from approximately 610 feet to 760 feet above mean sea level (msl) (see Figure 2-3 of the WP). IRP Site 1 includes the Northern Explosive Ordnance Disposal (EOD) Training Range (16.9 acres), the Southern EOD Training Range (16.6 acres), and a Buffer Zone (37 acres), among other features, for a total of approximately 74 acres (BNI 1995).

EOD training was conducted at IRP Site 1 from 1952 until closure of former MCAS El Toro on 2 July 1999. The majority of recent military EOD training took place at the Northern EOD Training Range. The Southern EOD Training Range was used for EOD training by the Orange County Sheriff's Department and various Federal agencies (BNI 1995). Several demolition pits, and a range building, are present at IRP Site 1. Military ordnance used at the Site included hand grenades, land mines, cluster bombs, smoke bombs, and rocket propelled munitions. Civilian commercial-grade explosives, such as dynamite, and plastic and gelatinous explosives have also been used at IRP Site 1. Trenches and pits were periodically excavated and munitions were detonated. The trenches and pits were then filled with soil and then subsequently reexcavated to conduct additional munitions detonation activities.

Limited historical information suggests that rocket motors or Jet-Assisted Take-Off units were handled at IRP Site 1. In 1982, approximately 2,000 gallons of sulfur trioxide chlorosulfonic acid (FS smoke) were reportedly burned in trenches located in the northern portion of the Site. An estimated 300,000 gallons of petroleum fuels were burned from 1952 through 1993. In addition, there are unconfirmed reports that low-level radioactive material was handled at the site (NEESA 1986). The potential presence of radionuclides at the Site was investigated and based on the investigation findings the site received unrestricted release from the California Department of Public Health in September 2007. The Department of Justice, Federal Bureau of Investigation (FBI) used IRP Site 1 for training purposes (FBI 2000). The FBI's activities at IRP Site 1 included bomb technician training, post-blast investigation training, and emergency response operations. These activities involved the use of explosive devices and products.

Previous investigations, described in the WP, resulted in recommendation for RA to address the perchlorate-impacted groundwater.

10.2 IRP SITE 2 LOCATION AND BACKGROUND

IRP Site 2 was used as a landfill, shown as Areas A and B on Figure 2-4 of the WP, from the late 1950s until about 1980, although some unauthorized disposal may have occurred on an intermittent basis at Areas C1, C2, and D2. During the 1970s, all solid waste from MCAS El Toro and some waste from MCAS Tustin were disposed in this landfill. Previous reports estimate 800,000 cubic yards to 1,000,000 cubic yards of waste were placed in the landfill during its operation (Strata 1991).

The suspected types of waste include construction debris, municipal waste, batteries, waste oils, hydraulic fluids, paint residues, transformers, and waste solvents (BNI 1996). A soil layer of varying thickness was placed over the landfill waste.

The RA for soil at IRP Site 2 was completed in February 2008. This RA included consolidation of wastes from Areas C1/C2, and D2, and construction of an evapotranspiration cap (AECOM 2009). The operation and maintenance (O&M) of this evapotranspiration cap is currently in progress.

Previous investigations, described in the Work Plan, resulted in recommendation for a Remedial Action to address the volatile organic compound (VOC)-impacted groundwater.

10.3 PROBLEM STATEMENT – IRP SITES 1 AND 2

Remedial actions will be implemented for groundwater associated with IRP Sites 1 and 2 consistent with the final remedies for both sites documented in the Groundwater Record of Decision (ROD) (DON 2012). The selected remedy for IRP Site 1 perchlorate-impacted groundwater consists of in-situ bioremediation (ISB) at the Source Area, downgradient of the Source Area between IRP Sites 1 and 2, near the former Station Boundary; and groundwater monitoring and institutional controls (ICs). The selected remedy for IRP Site 2 VOC-impacted groundwater will include monitored natural attenuation (MNA) and ICs. The conceptual site models for IRP Sites 1 and 2 presented in Section 3 of the WP were used as the basis of design for groundwater remedies for both sites (see Sections 6 and 7 of the WP for detailed engineering designs of groundwater remedies).

The primary problem is to evaluate if groundwater remedies for IRP Sites 1 and 2 are functioning properly and operating as designed. In addition, evaluations of progress toward attainment of remedial action objectives (RAOs) need to be made for both groundwater remedies. The RAOs for groundwater at IRP Sites 1 and 2 documented in the Groundwater ROD include the following:

- Minimize the potential for domestic use of groundwater with concentrations of chemicals of concern (COCs) exceeding the established respective remediation goals (RGs).
- Minimize migration of groundwater with concentrations of COCs exceeding the established respective RGs beyond the former MCAS El Toro Boundary.

The remediation goals (Table 10-1) are based on the most stringent of the following values: Federal maximum contaminant level (MCL), non-zero Federal maximum contaminant level goal (MCLG), and the State of California MCL and documented in the ROD (DON 2012).

Table 10-1: Remediation Goals – IRP Sites 1 and 2 Groundwater

COC	Selected RG (µg/L)[a]
IRP Site 1	
Perchlorate	6
IRP Site 2	
TCE	5
PCE	5
cis-1,2-DCE	6
1,2-DCA	0.5
1,1,2-TCA	3

Note:
[a] The most stringent of the following values: Federal MCL, non-zero Federal MCLG, and the State of California MCL.

1,2-DCA	1,2-dichloroethane
1,1,2-TCA	1,1,2-trichloroethane
µg/L	micrograms per liter
cis-1,2-DCE	cis-1,2-dichloroethene
COC	chemical of concern
IRP	Installation Restoration Program
PCE	tetrachloroethene
RG	remediation goal
TCE	trichloroethene

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SAP Worksheet #11: Project Quality Objectives/Systematic Planning Process Statements

11.1 DATA QUALITY OBJECTIVES FOR REMEDIAL ACTION AT IRP SITE 1

11.1.1 Goals of the Study

The following principal study questions have been developed to guide the sampling design:

1. Is the ISB remedy performing as designed and operating properly to protect human health and the environment?
2. Does the data confirm the attainment of RAOs/RGs for groundwater?

The above study questions have been expanded in a flow-chart presented on Figure 11-1 and the specific decision rules to resolve these study questions are presented in Section 11.1.4. This flow-chart also presents a comprehensive list of alternative actions for each identified question.

11.1.2 Information Inputs

The detailed in situ bioremediation (ISB) design and implementation strategy for IRP Site 1 groundwater are presented in Sections 6 and 8 of the main text of the Work Plan, respectively. ISB for perchlorate-impacted groundwater will include the following:

- Installation of an injected permeable reactive barrier (PRB) immediately downgradient of the Source Area (see Section 6.4 of the main text of the Work Plan for details)
- Active ISB within the Source Area using direct injection (see Section 6.4 of the main text of the Work Plan for details). ISB in the source area will be conducted within two hydraulic conductivity zones (Zone 1 and Zone 2) (see Figure 3-3 of the main text of the Work Plan).
- Installation of an injected PRB in the Intermediate Area between IRP Sites 1 and 2 (see Section 6.5 of the main text of the Work Plan for details)
- Installation of an injected PRB near the former Station Boundary where perchlorate from IRP Site 1 is commingled with VOC (primarily trichloroethene [TCE]) impacted groundwater from IRP Site 2 (see Section 6.5 of the main text of the Work Plan for details). The PRB at the Station Boundary will be designed to remediate perchlorate but will also lead to treatment of VOCs. Therefore, groundwater monitoring design for Station Boundary PRB will also include assessment VOCs in groundwater.

Groundwater monitoring conducted as part of ISB implementation will include collection of samples from wells upgradient, within, and downgradient of the reaction zones and analysis for various parameters to resolve the decisions identified in Section 11.1.1 in accordance with decision rules identified in Section 11.1.4. This will include evaluating the impacts of perchlorate in groundwater with respect to its RG of 6 micrograms per liter (µg/L) (see Table 10-1). The methods for groundwater sampling include low flow sampling and hydropunch sampling (see Standard Operating Procedure [SOP] No 3-14). The types and sources of information needed to resolve the study question is summarized in Table 11-1.

Table 11-1: Summary of Information Inputs

Type of Information/Environmental Characteristics	Primary Source of Information (Analytes)
Extent and rate of biodegradation of perchlorate and/or volatile organic compounds (VOCs)[a].	Collection of groundwater samples and analyses for perchlorate and VOCs[a].
Changes in geochemistry of groundwater due to substrate injection to evaluate if optimum conditions are created to stimulate indigenous bacteria to degrade perchlorate and/or VOCs.	DO, ORP, Anions[b], Methane
Evaluate if pH of groundwater is desirable for biological processes to occur.	pH
Indicator of biodegradation and the buffering capacity of the aquifer (neutralization of acids generated during substrate fermentation).	Alkalinity
Evaluate if TCE and cis-1,2-DCE are being completed dechlorinated to ethene and ethane.	Ethene[a], Ethane[a]
Indicator of substrate injection zone of influence	TOC, Bromide, geochemical parameters (DO, ORP, Anions[b], Methane), and COCs
Additional Parameters to evaluate aquifer permeability impacts due to ISB	Water level measurements and extraction flow rates during sampling.

Notes:
These analyses are not proposed for all groundwater samples/wells. See SAP Worksheet #18 for the complete list of proposed sampling locations and analyses.
[a] For Station Boundary PRB only.
[b] Anions include nitrate and sulfate.

cis-1,2-DCE	cis-1,2-dichloroethene
DO	dissolved oxygen
ORP	oxygen-reduction potential
pH	negative log of the hydrogen ion concentration
VOC	volatile organic compound

11.1.3 Study Boundaries

Figure 3-1 of the main text of the Work Plan presenting the extent of perchlorate-impacted groundwater at IRP Site 1, including monitoring wells and hydropunch locations at and downgradient of IRP Site 1, comprises the spatial boundaries of this study. The designs for PRBs and source area direct injection are presented in Section 6 of the main text of the Work Plan. The data to resolve decisions will be collected in the vicinity of the injection wells for substrate injection and the area between the ISB systems. Representative groundwater samples will be collected from the lateral and vertical extents of the target treatment zone. The data collection will continue until the RAOs/RGs for perchlorate-impacted groundwater are attained.

11.1.4 Analytic Approach

The decision rules for evaluating groundwater sampling results have been developed to support decisions based on multiple levels of evidence. The decision rules are:

- ***Decision Rule 1:*** If moderately reducing conditions as evident from parameters such as dissolved oxygen (DO) (less than approximately 2 milligrams per liter (mg/L) based on the pilot study results [AECOM and ECS 2011]), and oxygen-reduction potential (ORP) (less than approximately 200 milliVolts [mV] based on the pilot study results [AECOM and ECS 2011]) are created and total organic carbon (TOC) values exceeding the ambient value are reported along with near neutral negative log of the hydrogen ion concentration

(pH), then it will be concluded that sufficient quantity of electron donor has been injected to stimulate conditions conducive for anaerobic biodegradation of perchlorate.

- ***Decision Rule 2:*** If stable or declining TOC concentrations (approximately equivalent to ambient levels) in conjunction with little or no decrease in concentrations of perchlorate and alternate electron acceptors (e.g., DO) are observed, then it will be concluded that substrate is not present in sufficient quantity to sustain biodegradation. In this case, the need for additional substrate injection will be evaluated.
- ***Decision Rule 3:*** If the results of monitoring from cross-gradient monitoring wells located alongside the line of injection wells perpendicular to groundwater flow show an increase in TOC above ambient levels, a decreasing trend in DO or ORP, and/or a decreasing trend in perchlorate concentrations, then it will be concluded that adequate injection zone of influence has been attained to stimulate the bio-active zone to create a PRB. Else, further evaluation of data will be conducted using the following Decision Rule #4.
- ***Decision Rule 4:*** If the results from all monitoring wells downgradient of a PRB indicate a decreasing trend in perchlorate concentrations compared to upgradient wells, then it will be concluded that the bioactive zone created for perchlorate biodegradation is adequate. This evaluation will be made using perchlorate concentration hydrographs from wells upgradient and downgradient of PRBs.
- ***Decision Rule 5:*** If it is demonstrated to the satisfaction of the regulatory agencies that perchlorate concentrations are reduced to levels at or below its RG, verification monitoring will be initiated.
- ***Decision Rule 6:*** If verification monitoring data show that perchlorate concentrations remain at or below its RG for a period of 1 year, then performance monitoring will be terminated and recommendation for no further action will be made for groundwater at the site.

11.1.5 Performance or Acceptance Criteria

The PRBs and injection/monitoring wells were located based on previous investigations, periodic monitoring, and the best estimates of the location of contaminated groundwater. The decision rules include consideration of multiple lines of evidence to arrive at a decision and minimize the potential for decision error.

Decision errors resulting from measurement errors will be controlled by use of documented and approved analytical methods, standard operating procedures (SOPs) for sampling, and selection of analytical methods appropriate to the study.

11.1.6 Plan for Obtaining Data

Groundwater sampling in support of the remedial action at IRP Site 1 at the source area, and near the Station boundary, and Intermediate Area between IRP Sites 1 and 2 will include the following types of groundwater monitoring:

- Baseline groundwater sampling to characterize baseline concentrations of perchlorate and geochemical parameters prior to the start of ISB (*Baseline Monitoring*).
- Groundwater sampling in the vicinity of ISB implementation areas to evaluate the performance of ISB to treat perchlorate (*ISB Performance Monitoring*).

- Groundwater sampling over the entire extent of perchlorate-impacted groundwater including areas between active ISB areas to track distribution of perchlorate following the start of ISB (*Overall Perchlorate Extent Monitoring*).

11.1.6.1 BASELINE MONITORING

The baseline groundwater sampling will be a single event to characterize the baseline perchlorate concentrations, and geochemical conditions prior to emplacement of bioremediation substrate. Since perchlorate-impacted groundwater is commingled with IRP Site 2 VOC-impacted groundwater near the former Station Boundary, baseline monitoring for the IRP Site 1 remedy will also include groundwater sampling and analysis for VOCs to the extent necessary to evaluate future performance of Station Boundary PRB. The baseline groundwater sampling results will be compared with monitoring results following substrate emplacement to assess the performance of ISB. The baseline sampling plan is summarized in Table 18-1. The locations of monitoring wells mentioned in Table 18-1 in the source area and near the Station boundary, and in the area between IRP Sites 1 and 2 are presented on Figure 6-1 of the main text of the WP.

11.1.6.2 ISB PERFORMANCE MONITORING

The ISB performance monitoring will be conducted to evaluate the distribution of substrate, and assess changes in geochemical conditions and perchlorate concentrations due to biodegradation reactions. The ISB performance monitoring plans for Source Area PRB, Source Area Treatment, Intermediate Area PRB, and Station Boundary PRB are presented in Tables 18-2, 18-3, 18-4, and 18-5, respectively. The information obtained from each proposed analyte is presented in Table 11-1.

Tables 18-2, 18-4, and 18-5 present proposed monitoring locations for each PRB along with the rationale for the selection of each monitoring location. In general, for each PRB, groundwater sampling is proposed from the following locations:

- Upgradient wells (with respect to the proposed PRB locations and within the current plume configuration) to monitor influent COC concentrations in groundwater flowing into the PRBs.

- Injection/monitoring wells within the PRBs to assess the injection zone of influence and performance data within the PRB. These wells (in conjunction with downgradient monitoring wells) will be used to provide indication of emulsified vegetable oil (EVO) consumption and the need for replenishment of substrate.

- Downgradient monitoring wells to monitor effluent COC concentrations and effectiveness of the PRB. The data from these wells will be used in conjunction with wells within the PRB to evaluate if injection zone of influence is adequate to achieve biodegradation of perchlorate.

As discussed in detail in Section 3.1.3.2 of the main text of the Work Plan, perchlorate is commingled with VOCs (primarily TCE) near the Station Boundary. Therefore, the monitoring plan for the Station Boundary PRB will also include sampling and analysis for COCs and their biodegradation products including vinyl chloride (VC), ethene, ethane, and dissolved metals (see Table 18-5).

The ISB monitoring plan for treatment within the Source Area is presented in Table 18-3. Monitoring locations include representative injection and extraction wells within Zone 1, and all

injection wells within Zone 2 and upgradient of Zone 1 to evaluate decreases in perchlorate concentrations and changes in geochemistry. Zone 1 and Zone 2 are the two primary hydraulic conductivity zones identified near the central portion of IRP Site 1 based on the pump tests conducted in 2005 and 2006. These zones are shown on Figure 3-3 of the main text of the Work Plan.

11.1.6.3 Overall Perchlorate Extent Monitoring

Groundwater monitoring will be conducted over the entire extent of perchlorate-impacted groundwater including areas between active ISB areas to track the distribution of perchlorate following the start of ISB. Table 18-6 presents the optimized plan for overall perchlorate extent monitoring.

This plan is optimized based on the following:

1. Monitoring wells that satisfy all of the following criteria will be sampled once during Year 1: (a) wells have been routinely sampled at least once a year from July 2004 to March 2011, and perchlorate concentrations have been reported to be less than its RG during all monitoring rounds; (b) located upgradient of the perchlorate Source Area; and (c) based on the available data on perchlorate concentrations and direction of groundwater gradient, there is no potential for perchlorate to migrate from upgradient sources at concentrations exceeding it RG. The analytical results obtained from these wells will be evaluated as follows:
   - The well for which the perchlorate concentration is less than its RG will not be sampled further during the RA.
   - The well for which the perchlorate concentration exceeds its RG will be added to the list of wells monitored semi-annually for Years 1 through 3.
2. Monitoring wells for which perchlorate concentrations have exceeded its RG at least once during the past but the latest available data (as of January 2013) show perchlorate concentrations less than its RG, will be sampled semi-annually during Year 1 and the results will be evaluated as follows:
   - The well for which perchlorate concentrations are less than its RG during both monitoring rounds and for which there is no potential for perchlorate to migrate from upgradient sources at concentrations exceeding its RG (based on the available data on perchlorate concentrations and direction of groundwater gradient) will not be sampled further during the remedial action.
   - The well for which perchlorate concentrations exceed its RG at least once will be sampled semi-annually for Years 2 and 3.
3. Monitoring wells for which the latest available data (as of January 2013) show perchlorate concentrations exceeding its RG will be sampled semi-annually from Years 1 through 3 and the results will be evaluated as follows:
   - The well for which perchlorate concentrations are less than its RG during all monitoring rounds and for which there is no potential for perchlorate to migrate from upgradient sources at concentrations exceeding its RG (based on the available data on perchlorate

concentrations and direction of groundwater gradient) will not be sampled further during the RA.

- The well for which perchlorate concentrations exceed its RG at least once will be added to the list of wells monitored annually after Year 3. The current monitoring plan presented in Worksheet #18 shows that all monitoring wells proposed for semi-annual sampling during Years 1 through 3 will be sampled annually after Year 3. However, the monitoring program after Year 3 will be revised/optimized appropriately based on the results of the first three years of monitoring (see Section 11.1.6.4).
- The need for continued groundwater sampling and analysis from newly-installed monitoring wells 02_NEW07A, 02_NEW26A, 02_NEW27A, and 02-NEW42 will be evaluated following comprehensive review of PRB performance data and perchlorate distribution data near the Station Boundary.

11.1.6.4 Optimization of Monitoring Network/Schedule

The groundwater monitoring will be conducted for the IRP Site 1 remedy in accordance with the monitoring plan discussed above in Sections 11.1.6.1 through 11.1.6.3. After each monitoring round, data review will be conducted to evaluate progress toward attainment of short- and long-term objectives, and RAOs. The data review will also be performed to optimize the locations of monitoring points and proposed analyses. The optimization plan for the overall perchlorate extent monitoring is presented in Section 11.1.6.3. The monitoring program in support of ISB at the Source Area, Intermediate Area, and the former Station Boundary will also be optimized periodically to attain the data quality objectives (DQOs). The recommendations for optimization will be documented in the annual reports and/or in a field change request (FCR). This annual report/FCR will present the proposed optimization/change to the monitoring program along with the rationale for the change. Some examples of the scenarios where optimization of monitoring network/schedule may be required for ISB systems are presented below:

- The monitoring program may be revised/optimized to troubleshoot certain conditions such as decreases in pH due to substrate biodegradation reactions to the extent that it is shown to be detrimental to perchlorate-degrading microorganisms. A buffer may need to be injected in this case to revive perchlorate-degrading bacteria and the monitoring program may need to be modified with respect to well locations and analytes such as pH and alkalinity.
- Monitoring for anions (nitrate and sulfate) and methane may be discontinued for the Source Area and Intermediate Area PRBs if data collected for at least three monitoring rounds indicate little or no change to these parameters and if other parameters such as perchlorate, TOC, DO, and ORP are deemed to be sufficient to attain the monitoring objectives and evaluate geochemical conditions.

11.2 Data Quality Objectives for Remedial Action at IRP Site 2

11.2.1 Goals of the Study

The following study questions have been developed to guide the sampling design:

1. Is the selected remedy (MNA and ICs) performing as designed and operating properly to protect human health and the environment?

2. Does the data confirm the attainment of RAOs/RGs for groundwater?

11.2.2 Information Inputs

The RGs have been defined for the site-specific constituents of concern at IRP Site 2 shown in Table 10-1. To resolve the principal study question, the analytical results from the groundwater monitoring well sampling will be compared to the RGs for the site-specific COCs. Laboratory data, as shown in Worksheet 15, previous studies, shown in Worksheet 13, groundwater flow and transport model, and water level monitoring data and field parameter measurements collected during the past and future monitoring events are used as information inputs.

11.2.3 Study Boundaries

Figure 7-1 of the main text of the Work Plan presenting the extent of VOC-impacted groundwater at IRP Site 2, including monitoring wells for the MNA network, comprises the spatial boundaries of this study. The data collection will continue until the RAOs/RGs for IRP Site 2 VOC-impacted groundwater are attained.

11.2.4 Analytic Approach

Data evaluation discussed below includes analysis of changes (if any) to groundwater flow direction and rates, analysis of temporal (concentration versus time graph for all monitoring wells and Statistical hypothesis tests for detecting trends such as Mann-Kendall test), and spatial trends (mapping of COC concentration data in plan view and/or cross-section) in COC concentrations, analysis of COC concentrations in downgradient wells to evaluate plume migration, and to evaluate if RGs are attained. The decision rules for evaluating groundwater sampling results have been developed to support decisions based on multiple lines of evidence. The decision rules are:

- **Decision Rule 1:** If data evaluation indicates that COC concentrations in groundwater show a stable or decreasing trend, and sampling data shows COC concentrations less than their respective RGs in downgradient Wells 02_NEW27A and 02_NEW07A, then groundwater monitoring will continue as planned until the RGs are attained.
- **Decision Rule 2:** If data evaluation indicates that COC concentrations in one or more monitoring wells located within the plume show a significant increasing trend (inconsistent with the CSM and not originally anticipated during remedy selection), then the protectiveness of the remedy will be evaluated.
- **Decision Rule 3:** If data evaluation indicates that COC concentrations in one or more monitoring wells located within or at the leading edge of the plume show a significant increasing trend (inconsistent with the CSM and not originally anticipated during remedy selection), then the protectiveness of the remedy will be evaluated.
- **Decision Rule 4:** If it is demonstrated to the satisfaction of the regulatory agencies that COC concentrations are reduced to levels at or below their respective RGs, verification monitoring will be initiated.
- **Decision Rule 5:** If verification monitoring data show that COC concentrations remain at or below their respective RGs, then performance monitoring will be terminated and recommendation for no further action will be made for groundwater at the site.

11.2.5 Performance or Acceptance Criteria

The monitoring wells have been selected based primarily on the extent of TCE (the primary COC) in groundwater. The rationale for selection of each monitoring well is presented in Table 18-7. The study has been designed to include consideration of multiple lines of evidence to arrive at a decision and minimize the potential for decision error.

Decision errors resulting from measurement errors will be controlled by the use of documented and approved analytical methods, SOPs for sampling, and selection of analytical methods appropriate to the study.

11.2.6 Plan for Obtaining Data

MNA will include groundwater monitoring to evaluate potential migration and decreases in concentrations of COCs due to natural attenuation processes such as dilution, dispersion, sorption, and volatilization. Table 18-7 presents the proposed groundwater monitoring plan for IRP Site 2 MNA. The analytical parameters include VOCs and field parameters (DO, ORP, and pH). TCE has been reported at higher concentrations compared to other COCs and is also the most widespread COC in groundwater. Therefore, monitoring wells have been selected based primarily on the extent of TCE in groundwater. The rationale for selection of each monitoring well is presented in Table 18-7. The wells near the TCE plume boundary will be used to define the plume boundaries and will be sampled annually. The wells within the TCE plume will be sampled semi-annually for the first three years to evaluate decreases in COC concentrations due to natural attenuation mechanisms.

11.2.6.1 Optimization of Monitoring Network/Schedule

The groundwater monitoring will be conducted for the IRP Site 2 remedy in accordance with the monitoring plan discussed above. After each monitoring round, data review will be conducted to evaluate progress toward attainment of objectives and RAOs. The data review will also be performed to optimize the locations of monitoring points and proposed analyses. The recommendations for optimization will be documented in the annual reports and/or in a FCR. This annual report/FCR will present the proposed optimization/change to the monitoring program along with the rationale for the change. Some examples of the scenarios where optimization of monitoring network/schedule may be required are presented below:

- One or more wells included in the monitoring program to define the extent of the TCE plume may be deleted from the routine groundwater monitoring program if the following conditions are satisfied: (1) at least three years of performance monitoring data show COC concentrations below their respective RGs; and (2) data evaluation indicates that the plume is stable and there is no potential for COCs to migrate to the subject wells at concentrations exceeding their respective RGs in the future.
- One or more wells included in the monitoring program within the current extent of the TCE plume may be de deleted from the routine groundwater monitoring program if the following conditions are satisfied: (1) at least three years of performance monitoring data show COC concentrations below their respective RGs; and (2) there is no potential for COCs to migrate to the subject wells at concentrations exceeding their respective RGs in the future.

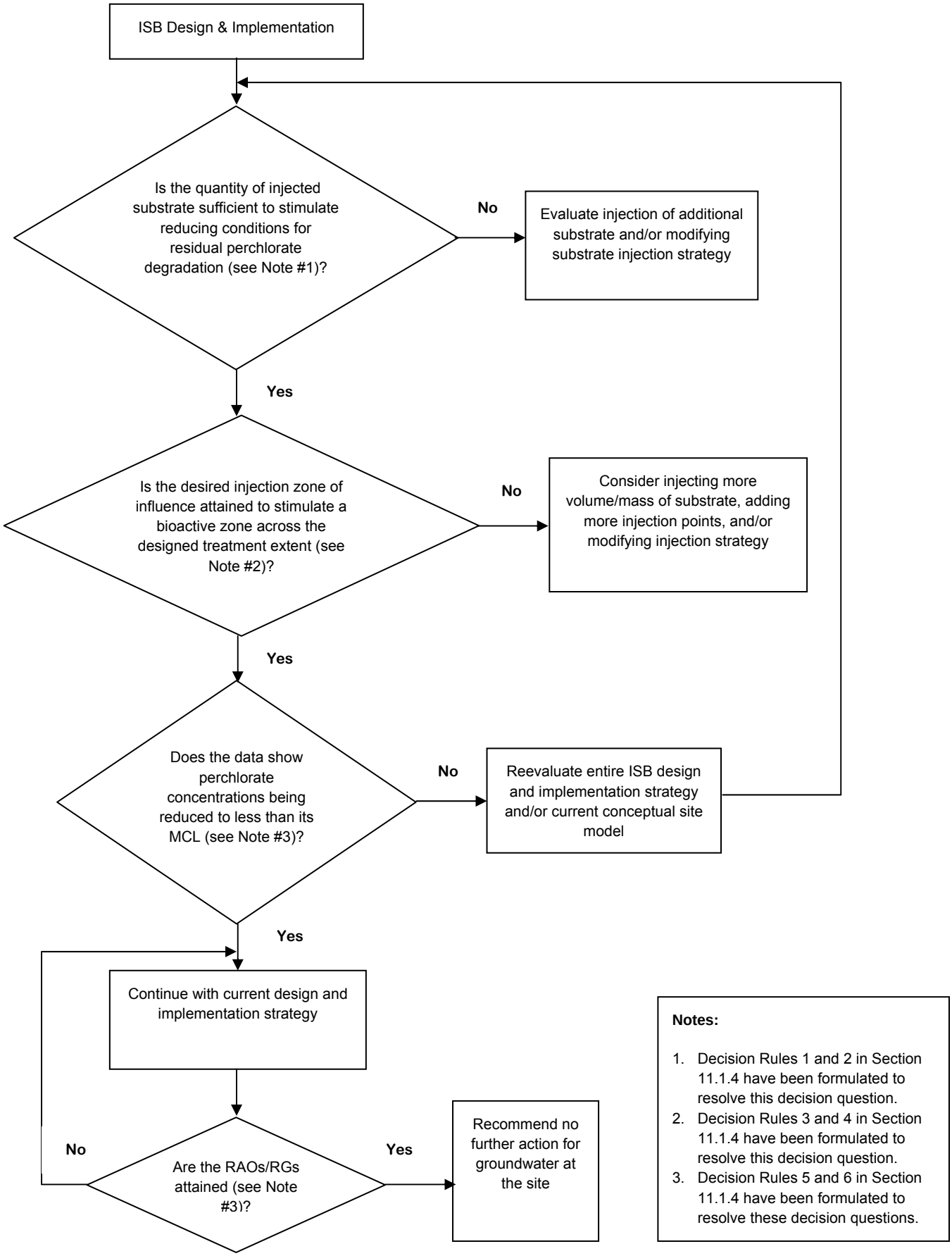

Figure 11-1: Summary of Decision Questions and Alternative Actions – IRP Site 1 Groundwater Remedy

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SAP Worksheet #12: Field Quality Control Samples

Measurement Performance Criteria Table – Field Quality Control Samples (Water)

QC Sample	Analytical Group	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria
Field duplicates	VOCs, Perchlorate, Anions/Tracers, Alkalinity, Total Organic Carbon, Metabolic Gases, Dissolved Metals	1:10	Precision	Laboratory acceptance limits for duplicates
Equipment Rinsate	VOCs and Perchlorate	1 per day	Representativeness and Accuracy/Bias	Less than PQL
Source Blank	VOCs and Perchlorate	1 per lot of DI water used for equipment rinsate collection	Representativeness and Accuracy/Bias	Less than PQL
Trip Blank	VOCs	1 per cooler of VOCs	Accuracy	No analyte > 1/2 PQL

Notes:
DI de-ionized
DQI data quality indicator
PQL project quantitation limit
QC quality control
VOC volatile organic carbon

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SAP Worksheet #13: Secondary Data Criteria and Limitations Table

Secondary Data Criteria and Limitations Table

Secondary Data	Data Source	Data Generator(s)	How Data Will Be Used	Limitations on Data Use
Groundwater Data	Final Groundwater Feasibility Study, Installation Restoration Program Sites 1 and 2, Former Marine Corps Air Station, El Toro, California. April 2011.	AECOM	Analytical data will be used to select groundwater monitoring well locations and direct push injection locations for the remedial action implementation at IRP Site 1 and groundwater monitoring locations for MNA at IRP Site 2.	No limitations – data were generated following Navy-approved SAP(FSP/QAPP)

Notes;
FSP field sampling plan
IRP installation restoration program
MNA monitored natural attenuation
QAPP quality assurance project plan
SAP sampling and analysis plan

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SAP Worksheet #14: Summary of Project Tasks

This worksheet summarizes the project tasks for this investigation.

14.1 MAJOR TASKS

- Utility Clearance and Anomaly Avoidance
- Geophysical Survey and Anomaly Avoidance
- Natural Resources Coordination
- Drilling and Well Installation
- Amendment Procurement and Storage
- Substrate Injection
- Groundwater Sampling
- Location Survey
- Remediation-Derived Waste

14.1.1 Utility Clearance

Utility clearance will be obtained prior to drilling by coordinating with the Navy, Federal Bureau of Investigation (FBI), and with City of Irvine/Great Park Corporation (for drilling activities within Carve-Out II-V-2). Underground utilities in the RA areas will be located by evaluating records including available site plans, utility layouts, and the results of any previous subsurface investigations. A Utility Clearance Request form, along with a map of proposed drilling locations and nearby utilities, will be submitted for approval. In addition, Dig Alert will be notified prior to the start of drilling activities.

14.1.2 Geophysical Survey and Anomaly Avoidance

Once approval has been obtained from the CSO, a nonintrusive geophysical survey will be conducted at each proposed drilling location at IRP Site 2 and at the Intermediate Area. There are no known subsurface utilities present within IRP Site 1. All geophysical activities will be supervised by a registered geophysicist certified by the State of California.

All proposed well locations will be marked with paint. Electromagnetic induction, ground penetrating radar, and magnetic geophysical techniques will then be used to search for existing underground utilities at the proposed well locations. These complementary techniques are used because underground utilities are made of many different materials (e.g. steel, aluminum, PVC, fiberglass, and cement).

A small grid (about 10 feet by 10 feet) will be constructed at each proposed well location. The grid will consist of one set of parallel profiles oriented approximately north-south and a second set of profiles oriented approximately east-west. Profile lines will be spaced 2 feet to 3 feet apart. Geophysical survey data will be continuously collected along all profiles. Anomalous data zones will be interpreted in real time by the geophysical operators. Locations of anomalies interpreted as representing buried objects will be marked on the ground and posted on the site base map.

Although there are no known subsurface utilities present within IRP Site 1, there is a potential for encountering material potentially presenting an explosive hazard (MPPEH). Therefore, anomaly

avoidance techniques will be employed to reduce the potential for encountering MPPEH. During anomaly avoidance, an unexploded ordnance (UXO) Technician will use a magnetometer to assist with avoiding MPPEH and other geophysical anomalies. The UXO Technician will first inspect the ground surface of the operational area to ensure that the surface is free of any metallic anomalies before intrusive operations can proceed. This surface inspection will include areas of ingress and egress. At the proposed drilling location, the UXO Technician will first check the location for subsurface anomalies prior to commencing any hand augering or drilling.

After confirming that the location is clear of metallic anomalies, drilling will commence. The first 5 feet of drilling will be conducted using a hand auger. Hand-augering will proceed in 1-foot lifts, and the excavated material will be piled no higher than 1-foot to allow evaluation for metallic anomalies. As hand augering continues, the location will be checked by the UXO Technician at 1-foot intervals until a depth of 5 feet below ground surface (bgs) is reached, at which point anomaly avoidance will no longer be required, and the drill rig will be used to advance the remainder of the borehole. During the subsurface anomaly checks, all metallic equipment will be moved far enough away from the excavation location so it does not interfere or mask any metallic subsurface anomalies. If a subsurface anomaly is detected in the borehole, the location will be abandoned and flagged for possible further follow-up. The immediate vicinity will be avoided. The proposed groundwater well will be moved to a nearby point that is clear of all metallic anomalies and hand augering will commence at the new location. No intrusive work will commence until the UXO Technician is satisfied that it is safe to do so. All activities will follow all requirements for anomaly avoidance set forth in the applicable Explosives Safety Submission (ESS) for the site to be prepared.

14.1.3 Natural Resources Coordination

The Draft RA WP was submitted to the United States Fish and Wildlife Service (USFWS) in June 2012. This Draft WP included environmental impact minimization measures presented below for review and comment by the USFWS.

Coastal sage scrub (CSS) has been observed at IRP Sites 1 and 2. As discussed in Section 8.3.3 of the main text of this RA WP, for IRP Site 1, some CSS may be near paths of ingress/egress for several existing wells that will receive injections; however, there are no proposed new wells near CSS locations. At IRP Site 2, CSS and mule fat scrub is adjacent to some drilling locations, and ingress/egress concerns may necessitate the trimming of some CSS to allow passage of drilling equipment. Less than 1/10th of an acre will require trimming to facilitate the installation of the four injection wells. Additionally, the proposed well drilling and substrate injection operations may have the potential to affect the coastal California gnatcatcher (CAGN), birds protected by the Migratory Bird Treaty Act (MBTA) (if present) and other sensitive species or their habitat. However, it is anticipated that the RA activities will have a negligible effect on CSS, the California gnatcatcher, and other sensitive species or their habitat because the following environmental impact minimization measures will be implemented during the field activities:• A qualified biological monitor, familiar with the ecology of the CAGN and possessing a Federal 10(a)(1)(A) permit for the CAGN, will be responsible for overseeing any activities that could disturb the CAGN within the project area.

- If the CAGN or any birds protected by the MBTA are found to be nesting, said nests will be marked by the biological monitor for avoidance during field activities, if work occurs during the breeding season.
- The qualified biological monitor will have the authority to suspend any activities within the project site that have the potential to adversely affect nesting CAGN. All such activities will

be postponed if they are found to occur within 200 feet of an active nest and will not resume until young have fledged and are sufficiently mobile to readily follow their parents, and evade disturbances.

- Efforts will be made to minimize impacts to habitat by trimming vegetation to the extent possible, rather than excavation and grading.
- After completion of the RA, a report of monitoring activities and results will be prepared and submitted to the USFWS.

14.1.4 Drilling and Well Installation

All drilling and well installation activities will be supervised by a California-registered geologist. Monitoring and injection well installation and development methods will follow AEJV SOP 3-12, Well Installation and Destruction (AEJV 2012).

14.1.4.1 Direct-Push Drilling

A total of 10 injection points will be advanced by direct-push techniques in support of the PRB at the Intermediate Area.

14.1.4.2 Hollow-Stem Auger Drilling

The following wells will be installed at IRP Site 1, the Intermediate Area, and IRP Site 2, using hollow-stem auger (HSA) techniques:

Table 14-1: Proposed Wells to be Installed at IRP Sites 1 and 2

Site	Number of Injection/Extraction Wells	Number of Monitoring Wells
IRP Site 1 Source Area PRB	2	2
IRP Site 1 Source Area PRB	15	--
Intermediate Area PRB	--	4
Station Boundary PRB	7	5
For MNA at IRP Site 2	--	3

14.1.4.3 Well Installation

All injection/extraction wells will be completed with 2-inch diameter Schedule 80 polyvinyl chloride (PVC) well screen and blank casing. All monitoring wells will be completed with 4-inch diameter Schedule 40 PVC well screen and blank casing.

Based on previous well installation at IRP Sites 1 and 2, all wells will be completed using 0.02-inch slot well screen and Lone Star #3 sand filter pack material. All well casings will be sealed at the bottom with a flush threaded end cap of the same material as the well screen. Screen and blank riser sections will be steam cleaned and wrapped in plastic for transportation to the well locations. The casing will remain wrapped in plastic until it is assembled and lowered down the borehole.

The well casing will be plumb and centered with centralizers placed every 20 feet, if necessary. Once the casing is installed, the filter pack, consisting of acid-resistant, washed and graded silica sand, will be placed by tremie pipe down the annulus between the well casing and the borehole wall. The sand will be furnished in sacks and will be certified clean and free of oil, acids, and organic and

other deleterious materials. The filter pack will be placed from the bottom of the borehole to 2 feet above the top of the well screen or between the bentonite seals for the multi-screen wells. The filter pack depth will be periodically sounded to monitor the depth and to locate any points of bridging between the well casing and the borehole wall. Potable water may be poured down the annulus to break bridges if they are encountered. The amount of water introduced into the well will be kept to a minimum and the quantities will be recorded in the field logbook.

The volume of filter pack material used will be recorded in the field logbook during filter pack construction. The volume of sand used will be compared to the volume of annulus filled every 5 feet to 10 feet. If a significant discrepancy arises between the sand volume used versus the filled volume measured, the source of this error will be identified and corrected.

Wells will be predeveloped by bailing and surging to aid in settling the filter pack before placing the bentonite seal. After the filter pack has been placed, a 2-foot to 5-foot sodium bentonite seal (either granular for unsaturated conditions or coated pellet form for saturated conditions) will be introduced into the well above the filter pack. The bentonite will be saturated with potable water and allowed to hydrate for at least 1 hour. After the bentonite seal has hydrated, the remaining annulus will be grouted using a Type I Portland or American Petroleum Institute (API) Class A cement/bentonite slurry.

14.1.4.4 Well Development

Each newly-installed well will be developed no sooner than 24 hours following well completion in accordance with AEJV SOP 3-12, Well Installation and Destruction (AEJV 2012).

14.1.4.5 Armoring of Wells Installed in Borrego Canyon Wash

Due to the extremely high water flow conditions that occasionally occur within Borrego Canyon Wash near the proposed Station Boundary PRB, additional armoring is proposed to prevent damages. A 24-inch diameter steel casing is proposed to be advanced using air-knife techniques to a depth of 4 feet bgs. The casing will stick up to the height of the monitoring well monument. Within that outer casing, a 12-inch steel casing will be advanced to a depth of 18 feet bgs. The injection or monitoring well will then be installed within the 12-inch steel casing.

14.1.5 Amendment Procurement and Storage

The substrate will be delivered to the site in 1,000-liter totes. Because it is a more secure location, the staging area for the totes will be within IRP Site 1. When needed for injection activities, the totes will be moved on pallets using a backhoe or forklift.

14.1.6 Substrate Injection

The substrate will be amended to the subsurface by introducing a volume of water containing the desired concentration to a well or set of wells. A minimal amount of that water will come from extraction at wells near the injection wells. The remainder will be provided by a hydrant located between IRP Sites 1 and 2. A water truck will transport the hydrant water to on-site tanks.

14.1.7 Groundwater Sampling

The proposed number of groundwater samples is presented in Worksheet #18, and will be collected in accordance with Worksheet #14 and AEJV SOP 3-14. The rationale for the number of samples is presented in Worksheet #11.

14.1.8 Location Survey

Each newly-installed well and direct-push injection point will be referenced to standard horizontal control and vertical control by a California-licensed land surveyor. For wells, the measuring point will be clearly and permanently marked on the northern side of the inside well casing for future water level measurements. Vertical elevations of the casings and elevations of the ground surface will be measured to the nearest 0.01-foot, referenced to msl. The horizontal location will be measured to the nearest 0.1-foot, referenced to msl. All points will be surveyed to North American Datum 83 California State Plane Coordinate System Zone 6 for horizontal control, and National American Vertical Datum 88 for vertical datum, including translation into latitude and longitude coordinates (horizontal datum).

14.1.9 Remediation-Derived Waste Management

All remediation-derived waste will be managed appropriately. Remediation-derived waste includes the following:

- Cuttings from injection and monitoring well boreholes
- Groundwater generated from development of new wells
- Groundwater generated from purging of wells prior to sampling
- Decontamination fluids
- Disposable protective clothing and supplies.

Procedures for handling these wastes are discussed in the following sections.

14.1.9.1 Soil

Soil cuttings generated during borehole drilling will be placed in plastic-lined rolloff bins at the site. All rolloff bins will be labeled with borehole or well number, depth interval, date generated, and contents. To obtain representative samples, a composite sample from each rolloff bin will be analyzed for contaminants historically reported in soil at the site. If VOC analysis is required, two discrete samples will be collected from each rolloff bin. The composite sample will be collected as follows: approximately equal amounts of soil will be removed from four areas within the rolloff bin using a stainless steel trowel and placed in a stainless steel bowl; the soil will be mixed in the bowl; the mixed soil will then be placed in an 8-ounce glass jar and prepared for shipment to the laboratory.

Analytical results will be compared with regulatory criteria and standards to assess if the sampled material can be returned to the site or must be disposed at an approved waste facility as either nonhazardous or hazardous waste.

14.1.9.2 Well Development/Purge Water and Decontamination Fluids

Water purged from wells during well development or during decontamination of drilling equipment will be placed in 55-gallon drums. Composite samples will be collected from not more than four drums each, and analyzed for contaminants historically reported in groundwater at the site. Analytical results will be compared with regulatory criteria and standards to assess if the sampled water will be disposed off-site at an approved waste facility as either nonhazardous or hazardous waste.

14.1.9.3 DISPOSABLE PROTECTIVE CLOTHING

All disposable protective clothing and supplies will be presumed non-hazardous and will be disposed as nonhazardous waste at an appropriate waste facility.

SAP Worksheet #15: Reference Limits and Evaluation Table

Matrix: **Groundwater**

Analyte	CAS No.	Project AL (applicable limits)	Project AL Reference	Project QL Goal (applicable units)	Laboratory Specific Limits		
					LOQs	LODs	DLs
Total Organic Carbon (TOC) (mg/L)	--	--	--	1	1	0.5	0.25
Alkalinity (mg/L)	--	--	--	5	5	5	5
Perchlorate (µg/L)	14797-73-0	6	ROD (DON 2012)	2	2	1	0.5
Metabolic gases (µg/L)							
Ethene	74-85-1	--	--	2	2	0.60	0.30
Ethane	74-84-0	--	--	2	2	0.64	0.32
Methane	74-82-8	--	--	2	2	0.34	0.17
Anions/Tracers (mg/L)							
Nitrate	7697-37-2	--	--	0.2	0.1	0.05	.025
Sulfate	14808-79-8	--	--	0.5	0.5	0.25	.13
Bromide	24959-67-9	--	--	0.5	0.5	0.25	.13
VOCs (µg/L)							
Trichloroethene	79-01-6	5	ROD (DON 2012)	0.5	0.5	0.2	0.10
Tetrachloroethene	127-18-4	5	ROD (DON 2012)	1	1	0.2	0.15
cis-1,2-Dichloroethene	156-59-2	6	ROD (DON 2012)	1	1	0.2	0.10
Vinyl Chloride	75-01-4	0.5	ROD (DON 2012)	0.5	0.5	0.2	0.12
1,1,2-trichloroethane	79-00-5	3	ROD (DON 2012)	1	1	0.2	0.10
1,2-dichloroethane	107-06-2	0.5	ROD (DON 2012)	0.5	0.5	0.2	0.10
Metals (mg/L)							

Analyte	CAS No.	Project AL (applicable limits)	Project AL Reference	Project QL Goal (applicable units)	Laboratory Specific Limits		
					LOQs	LODs	DLs
Aluminum	7429-90-5	1	--	0.1	0.1	0.02	0.01
Antimony	7440-36-0	0.006	--	0.001	0.001	0.0005	0.00025
Arsenic	7440-38-2	0.010	--	0.001	0.001	0.0002	0.0001
Barium	7440-39-3	1	--	0.001	0.001	0.0005	0.00025
Beryllium	7440-41-7	0.004	--	0.001	0.001	0.0001	0.00005
Cadmium	7440-43-9	0.005	--	0.001	0.001	0.0002	0.0001
Calcium	7440-70-2	--	--	0.1	0.1	0.025	0.013
Chromium	7440-47-3	0.05	--	0.001	0.001	0.0002	0.0001
Cobalt	7440-48-4	--	--	0.001	0.001	0.0002	0.0001
Copper	7440-50-8	1	--	0.001	0.001	0.0005	0.00025
Iron	7439-89-6	--	--	0.1	0.1	0.01	0.005
Lead	78-00-2	0.015	--	0.001	0.001	0.0001	0.00005
Magnesium	7439-95-4	--	--	0.1	0.1	0.01	0.005
Manganese	7439-96-5	--	--	0.001	0.001	0.0002	0.0001
Mercury	7487-94-7	0.002	--	0.0005	0.0005	0.0001	0.000054
Nickel	7440-02-0	0.1	--	0.001	0.001	0.0002	0.0001
Potassium	7440-09-7	--	--	0.1	0.1	0.02	0.01
Selenium	7782-49-2	0.05	--	0.001	0.001	0.0003	0.00015

Analyte	CAS No.	Project AL (applicable limits)	Project AL Reference	Project QL Goal (applicable units)	Laboratory Specific Limits		
					LOQs	LODs	DLs
Silver	7440-22-4	--	--	0.001	0.001	0.0002	0.0001
Sodium	7440-23-5	--	--	0.1	0.1	0.05	0.025
Thallium	7440-28-0	2	--	0.001	0.001	0.0002	0.0001
Vanadium	7440-62-2	--	--	0.001	0.001	0.0005	0.00025
Zinc	7440-66-6	--	--	0.02	0.02	0.01	0.005

Notes:

AL	action limit
DL	detection limit
LOD	limit of detection
LOQ	limit of quantification
mg/L	milligram per liter
QL	quantitation limit
TOC	total organic carbon
µg/L	microgram per Liter
UFP	Uniform Federal Policy
U.S. EPA	United States, Environmental Protection Agency
VOC	volatile organic compound

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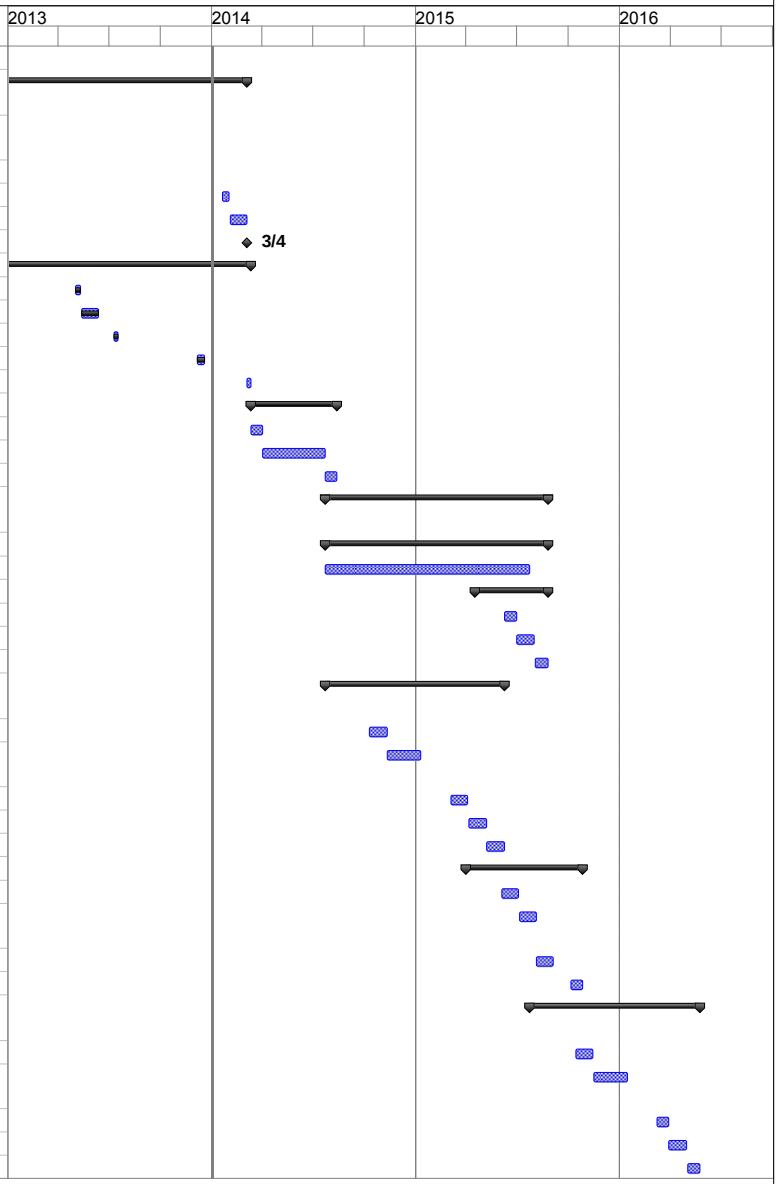
SAP Worksheet #16 Project Schedule/Timeline
IRP Sites 1 and 2 - Groundwater Post ROD Schedule
Former MCAS El Toro

ID	Task Name	Duration	Start	Finish
2089	Final ROD	0 days	Wed 2/15/12	Wed 2/15/12
2090	**Remedial Design/ Action Work Plan (RD/RA- WP)**	**558 days**	**Fri 1/13/12**	**Tue 3/4/14**
2093	Draft (RD/RA- WP) - Preliminary Remedial Design	25 days	Wed 5/2/12	Tue 6/5/12
2095	Regulatory Agency Review	58 days	Wed 6/6/12	Fri 8/24/12
2103	Draft Final (RD/RA- WP)	10 days	Mon 1/20/14	Fri 1/31/14
2105	Regulatory Agency Concur/Dispute	22 days	Mon 2/3/14	Tue 3/4/14
2106	Final (RD/RA- WP)	0 days	Tue 3/4/14	Tue 3/4/14
2108	**Remedial Action (RA) Fact Sheet**	**372 days**	**Mon 10/8/12**	**Tue 3/11/14**
2111	Draft RA Fact Sheet	7 days	Thu 5/2/13	Fri 5/10/13
2113	Regulatory Agency Review	22 days	Mon 5/13/13	Tue 6/11/13
2116	Draft Final RA Fact Sheet	5 days	Wed 7/10/13	Tue 7/16/13
2118	Regulatory Agency Concur/Dispute	9 days	Fri 12/6/13	Wed 12/18/13
2119	Final RA Fact Sheet	5 days	Wed 3/5/14	Tue 3/11/14
2121	**Remedial Action Construction**	**110 days**	**Wed 3/12/14**	**Tue 8/12/14**
2122	Mobilization	15 days	Wed 3/12/14	Tue 4/1/14
2123	Implementation	80 days	Wed 4/2/14	Tue 7/22/14
2124	Site Restoration	15 days	Wed 7/23/14	Tue 8/12/14
2125	**Remedial Action Operations/Long Term Monitoring**	**285 days**	**Wed 7/23/14**	**Tue 8/25/15**
2126	**Year 1 (2013-2014)**	**285 days**	**Wed 7/23/14**	**Tue 8/25/15**
2127	Routine Monitoring/Sampling/Reporting	262 days	Wed 7/23/14	Thu 7/23/15
2128	**Annual Report (2013-2014)**	**93 days**	**Fri 4/17/15**	**Tue 8/25/15**
2131	Draft Annual Report	16 days	Tue 6/9/15	Tue 6/30/15
2132	Regulatory Agency Review	23 days	Wed 7/1/15	Fri 7/31/15
2133	Final Annual Report	17 days	Mon 8/3/15	Tue 8/25/15
2134	**Interim Remedial Action Completion Report (I-RACR)**	**229 days**	**Wed 7/23/14**	**Mon 6/8/15**
2137	Draft I-RACR	22 days	Fri 10/10/14	Mon 11/10/14
2139	Regulatory Agency Review (Appendix A : 10/30/13)	44 days	Tue 11/11/14	Fri 1/9/15
2142	Draft Final I-RACR	22 days	Thu 3/5/15	Fri 4/3/15
2143	Regulatory Agency Concur/Dispute	24 days	Mon 4/6/15	Thu 5/7/15
2144	Final I-RACR	22 days	Fri 5/8/15	Mon 6/8/15
2146	**Long Term Monitoring (LTM) Plan**	**149 days**	**Wed 4/1/15**	**Mon 10/26/15**
2149	Draft LTM Plan	22 days	Thu 6/4/15	Fri 7/3/15
2151	Regulatory Agency Review (Appendix A : 6/24/14)	22 days	Mon 7/6/15	Tue 8/4/15
2152	Response to Comments	22 days	Wed 8/5/15	Thu 9/3/15
2154	Final LTM Plan	15 days	Tue 10/6/15	Mon 10/26/15
2156	**Operating Properly and Successfully (OPS) Demonstration Report**	**217 days**	**Fri 7/24/15**	**Mon 5/23/16**
2159	Draft OPS Demonstration Report	22 days	Thu 10/15/15	Fri 11/13/15
2161	Regulatory Agency Review (Appendix A : 11/4/14)	44 days	Mon 11/16/15	Thu 1/14/16
2164	Draft Final OPS Demonstration Report	15 days	Tue 3/8/16	Mon 3/28/16
2165	Regulatory Agency Concur/Dispute	24 days	Tue 3/29/16	Fri 4/29/16
2166	Final OPS Demonstration Report	16 days	Mon 5/2/16	Mon 5/23/16



Project: Former MCAS El Toro
Date:Thu 1/2/14

Task | Milestone | Summary | Project Summary | Progress

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SAP Worksheet #17: Sampling Design and Rationale

Remedial actions will be implemented for groundwater associated with IRP Sites 1 and 2 consistent with the final remedies for both sites documented in the Groundwater ROD (DON 2012). The selected remedy for IRP Site 1 perchlorate-impacted groundwater consists of ISB at the Source Area, downgradient of the Source Area between IRP Sites 1 and 2, near the former Station Boundary; and groundwater monitoring and ICs. The selected remedy for IRP Site 2 VOC-impacted groundwater will include MNA and ICs.

The primary problem is to evaluate if groundwater remedies for IRP Sites 1 and 2 are functioning properly and operating as designed. In addition, evaluations of progress toward attainment of RAOs need to be made for both groundwater remedies. The RAOs for groundwater at IRP Sites 1 and 2 documented in the Groundwater ROD include the following:

1. Minimize the potential for domestic use of groundwater with concentrations of COCs exceeding the established respective RGs.
2. Minimize migration of groundwater with concentrations of COCs exceeding the established respective RGs beyond the former MCAS El Toro Boundary.

The remediation goals (Table 10-1) are based on the most stringent of the following values: Federal MCL, non-zero Federal MCLG, and the State of California MCL and documented in the ROD (DON 2012).

The proposed number of groundwater samples is presented in Worksheet #18, and will be collected in accordance with Worksheet #14 and AEJV SOP 3-14. The rationale for the number of samples as described in Worksheet #11 is as follows:

17.1 Baseline Monitoring at IRP Site 1

The baseline groundwater sampling will be a single-event to characterize the baseline perchlorate concentrations, and geochemical conditions prior to emplacement of bioremediation substrate. Since perchlorate-impacted groundwater is commingled with IRP Site 2 VOC-impacted groundwater near the former Station Boundary, baseline monitoring for the IRP Site 1 remedy will also include groundwater sampling and analysis for VOCs to the extent necessary to evaluate future performance of Station Boundary PRB. The baseline groundwater sampling results will be compared with monitoring results following substrate emplacement to assess the performance of ISB (see Worksheet #18).

17.2 ISB Performance Monitoring at IRP Site 1

The ISB performance monitoring will be conducted to evaluate distribution of substrate, and assess changes in geochemical conditions and perchlorate concentrations due to biodegradation reactions (see Worksheet #18).

17.3 Overall Perchlorate Extent Monitoring at IRP Site 1

Groundwater monitoring will be conducted over the entire extent of perchlorate-impacted groundwater including areas between active ISB areas to track distribution of perchlorate following the start of ISB (see Worksheet #18).

17.4 MONITORING NETWORK AND SCHEDULE AT IRP SITE 2

MNA will include groundwater monitoring to evaluate potential migration and decreases in concentrations of COCs due to natural attenuation processes such as dilution, dispersion, sorption, and volatilization (see Worksheet #18).

SAP Worksheet #18: Location-Specific Sampling Methods/SOP Requirements Table

Table 18-1: Sampling Locations/IDs and Sample Analyses – Baseline Groundwater Monitoring Plan, IRP Site 1

Sample Location/ ID Number	Matrix	Depth[c] (ft bgs)	Analytical Groups	Sampling SOP Reference
Source Area				
01-EW05	Groundwater	40	Perchlorate, DO, ORP, pH	SOP No. 3-14
01-EW07	Groundwater	60	Perchlorate, DO, ORP, pH	SOP No. 3-14
01-EW09	Groundwater	60	Perchlorate, DO, ORP, pH	SOP No. 3-14
01-IW05	Groundwater	60	Perchlorate, DO, ORP, pH	SOP No. 3-14
01-IW06	Groundwater	80	Perchlorate, DO, ORP, pH, Alkalinity, Anions[a], Methane, Bromide, TOC	SOP No. 3-14
01-IW07	Groundwater	50	Perchlorate, DO, ORP, pH, Alkalinity, Anions[a], Methane, Bromide, TOC	SOP No. 3-14
01-IW09	Groundwater	55	Perchlorate, DO, ORP, pH	SOP No. 3-14
01-IW10	Groundwater	50	Perchlorate, DO, ORP, pH	SOP No. 3-14
01-IW14	Groundwater	65	Perchlorate, DO, ORP, pH	SOP No. 3-14
01-PZ21B	Groundwater	60	Perchlorate, DO, ORP, pH	SOP No. 3-14
Source Area PRB				
01-IW03	Groundwater	45	Perchlorate, DO, ORP, pH	SOP No. 3-14
01-IW04	Groundwater	45	Perchlorate, DO, ORP, pH	SOP No. 3-14
01-MW205	Groundwater	40	Perchlorate, DO, ORP, pH	SOP No. 3-14
Between Source Area and Intermediate PRBs				
01-DGMW57	Groundwater	73	Perchlorate, DO, ORP, pH	SOP No. 3-14
01-MW207	Groundwater	37.5	Perchlorate, DO, ORP, pH	SOP No. 3-14
01-MW217	Groundwater	62.5	Perchlorate, DO, ORP, pH	SOP No. 3-14
01-PZ14	Groundwater	37.5	Perchlorate, DO, ORP, pH	SOP No. 3-14
18BGMW24	Groundwater	50	Perchlorate, DO, ORP, pH	SOP No. 3-14
Intermediate PRB				
01-DPT01[b]	Groundwater	35	Perchlorate, DO, ORP, pH	SOP No. 3-14

Sample Location/ ID Number	Matrix	Depth[c] (ft bgs)	Analytical Groups	Sampling SOP Reference
01-DPT02[b]	Groundwater	35	Perchlorate, DO, ORP, pH	SOP No. 3-14
01-DPT09[b]	Groundwater	45	Perchlorate, DO, ORP, pH	SOP No. 3-14
01-DPT10[b]	Groundwater	45	Perchlorate, DO, ORP, pH	SOP No. 3-14
01-MW233	Groundwater	45	Perchlorate, DO, ORP, pH, Alkalinity, Anions[a], Methane, Bromide, TOC	SOP No. 3-14
Between Intermediate and Station Boundary PRBs				
02NEW16	Groundwater	45	Perchlorate, DO, ORP, pH	SOP No. 3-14
Station Boundary PRB				
02-IW05	Groundwater	80	Perchlorate, DO, ORP, pH, VOCs[d]	SOP No. 3-14
02-IW08	Groundwater	80	Perchlorate, DO, ORP, pH	SOP No. 3-14
02-NEW38	Groundwater	80	Perchlorate, VOCs[d], DO, ORP, pH, Alkalinity, Anions[a], Methane, Ethane, Ethene, Bromide, TOC	SOP No. 3-14

Notes:
[a] Anions include nitrate and sulfate
[b] Hydropunch samples
[c]The depth of the sample represents the middle of the screen interval of the monitoring well.
[d] VOCs include TCE, PCE, , cis-1,2-DCE, 1,2-DCA, 1,1,2-TCA and VC.

Table 18-2: Sampling Locations/IDs and Sample Analyses – ISB Performance Monitoring Plan for Source Area PRB at IRP Site 1

Sample Location/ ID Number	Matrix	Depth[a] (ft bgs)	Analytical Groups				Sampling SOP Reference	Rationale for Sampling Location
			First Month (Single Event)[b]	Year 1 (Quarterly)	Years 2 and 3 (Semi-Annually)	After Year 3 (Annually)		
01-IW01	Groundwater	42.5	DO, ORP, pH, Bromide, TOC	Perchlorate, DO, ORP, pH, Alkalinity, Anions[c], Methane, Bromide, TOC	Perchlorate, DO, ORP, pH, Alkalinity, Anions[c], Methane, TOC	Perchlorate, DO, ORP, pH, Alkalinity, Anions[c], Methane, TOC	SOP No. 3-14	Performance data within the PRB
01-MW225A	Groundwater	35	DO, ORP, pH, Bromide, TOC	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	SOP No. 3-14	Upgradient well for monitoring influent concentrations
01-MW225B	Groundwater	48.5	DO, ORP, pH, Bromide, TOC	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	SOP No. 3-14	Upgradient well for monitoring influent concentrations
01-MW229	Groundwater	45	DO, ORP, pH, Bromide, TOC	Perchlorate, DO, ORP, pH, Alkalinity, Anions[c], Methane, Bromide, TOC	Perchlorate, DO, ORP, pH, Alkalinity, Anions[c], Methane, TOC	Perchlorate, DO, ORP, pH, Anions[c], Methane, TOC	SOP No. 3-14	Performance data within the PRB; assessment of injection zone of influence
01MW230	Groundwater	45	DO, ORP, pH, Bromide, TOC	Perchlorate, DO, ORP, pH, Bromide	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	SOP No. 3-14	Downgradient well to monitor effluent concentrations and PRB effectiveness
01-PZ21A	Groundwater	33.5	DO, ORP, pH, Bromide, TOC, Dissolved Metals	Perchlorate, DO, ORP, pH, Bromide, Dissolved Metals	Perchlorate, DO, ORP, pH, Dissolved Metals	Perchlorate, DO, ORP, pH, Dissolved Metals	SOP No. 3-14	Downgradient well to monitor effluent concentrations and PRB effectiveness

Notes:

--- not applicable/not being sampled for that event

[a] The depth of the sample represents the middle of the screen interval of the monitoring well.

[b] To be conducted within 15 to 30 days of the completion of substrate injection

[c] Anions include nitrate and sulfate.

Table 18-3: Sampling Locations/IDs and Sample Analyses – ISB Performance Monitoring Plan for Source Area Treatment at IRP Site 1

Sample Location/ ID Number	Matrix	Depth[a] (ft bgs)	Analytical Groups				Sampling SOP Reference	Rationale for Sampling Location
			First Month (Single Event)[b]	Year 1 (Quarterly)	Years 2 and 3 (Semi-Annually)	After Year 3 (Annually)		
01-EW05	Groundwater	40	DO, ORP, pH, Bromide, TOC	Perchlorate, DO, ORP, pH, Alkalinity, Anions[c], Methane, Bromide, TOC	Perchlorate, DO, ORP, pH, Alkalinity, Anions[c], Methane, TOC	Perchlorate, DO, ORP, pH, Alkalinity, Anions[c], Methane, TOC	SOP No. 3-14	Performance data for extraction well within Zone 1
01-EW07	Groundwater	60	DO, ORP, pH, Bromide, TOC	Perchlorate, DO, ORP, pH, Anions[c], Bromide, TOC	Perchlorate, DO, ORP, pH, Anions[c], TOC	Perchlorate, DO, ORP, pH, Anions[c], TOC	SOP No. 3-14	Performance data for extraction well within Zone 1
01-IW10	Groundwater	50	DO, ORP, pH, Bromide, TOC	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	SOP No. 3-14	Performance data for injection well within Zone 1
01-MW209	Groundwater	35	DO, ORP, pH, Bromide, TOC	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	SOP No. 3-14	Performance data near extraction well 01-EW02B within Zone 1
01-MW219	Groundwater	47.5	DO, ORP, pH, Bromide, TOC	Perchlorate, DO, ORP, pH, Anions[c], Bromide, TOC	Perchlorate, DO, ORP, pH, Anions[c], TOC	Perchlorate, DO, ORP, pH, Anions[c], TOC	SOP No. 3-14	Performance data for extraction well within Zone 1
01-PZ07	Groundwater	42.5	DO, ORP, pH, Bromide, TOC	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	SOP No. 3-14	Performance data near extraction well 01-EW04 within Zone 1
01-PZ09	Groundwater	42.5	DO, ORP, pH, Bromide, TOC	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	SOP No. 3-14	Performance data for injection well within Zone 1
01-PZ11	Groundwater	47.5	DO, ORP, pH, Bromide, TOC	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	SOP No. 3-14	Performance data for injection well within Zone 1
01-IW14	Groundwater	65	DO, ORP, pH, Bromide, TOC	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	SOP No. 3-14	Performance data for injection

Sample Location/ ID Number	Matrix	Depth[a] (ft bgs)	Analytical Groups				Sampling SOP Reference	Rationale for Sampling Location
			First Month (Single Event)[b]	Year 1 (Quarterly)	Years 2 and 3 (Semi-Annually)	After Year 3 (Annually)		
								well within Zone 2
01-MW202	Groundwater	22.5	DO, ORP, pH, Bromide, TOC	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	SOP No. 3-14	Performance data for injection well upgradient of Zone 1
01-MW203	Groundwater	44.5	DO, ORP, pH, Bromide, TOC	Perchlorate, DO, ORP, pH, Alkalinity, Anions[c], Bromide, TOC	Perchlorate, DO, ORP, pH, Alkalinity, Anions[c], TOC	Perchlorate, DO, ORP, pH, Alkalinity, Anions[c], TOC	SOP No. 3-14	Performance data for injection well upgradient of Zone 1
01-PZ03	Groundwater	42.5	DO, ORP, pH, Bromide, TOC	Perchlorate, DO, ORP, pH, Alkalinity, Anions[c], Bromide, TOC	Perchlorate, DO, ORP, pH, Alkalinity, Anions[c], TOC	Perchlorate, DO, ORP, pH, Alkalinity, Anions[c], TOC	SOP No. 3-14	Performance data for injection well upgradient of Zone 1
01-PZ08	Groundwater	67.5	DO, ORP, pH, Bromide, TOC	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	SOP No. 3-14	Performance data for injection well within Zone 2
01-PZ20	Groundwater	55	DO, ORP, pH, Bromide, TOC	Perchlorate, DO, ORP, pH, Alkalinity, Anions[c], Methane, Bromide, TOC	Perchlorate, DO, ORP, pH, Alkalinity, Anions[c], Methane, TOC	Perchlorate, DO, ORP, pH, Alkalinity, Anions[c], Methane, TOC	SOP No. 3-14	Performance data for injection well within Zone 2

Notes:

[a] The depth of the sample represents the middle of the screen interval of the monitoring well.

[b] To be conducted within 15 to 30 days of the completion of substrate injection

[c] Anions include nitrate and sulfate.

Table 18-4: Sampling Locations/IDs and Sample Analyses – ISB Performance Monitoring Plan for Intermediate Area PRB at IRP Site 1

Sample Location/ ID Number	Matrix	Depth[a] (ft bgs)	Analytical Groups				Sampling SOP Reference	Rationale for Sampling Location
			First Month (Single Event)[b]	Year 1 (Quarterly)	Years 2 and 3 (Semi-Annually)	After Year 3 (Annually)		
01-MW214	Groundwater	40.5	DO, ORP, pH, Bromide, TOC	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	SOP No. 3-14	Upgradient well for monitoring influent concentrations
01-MW231	Groundwater	45	DO, ORP, pH, Bromide, TOC	Perchlorate, DO, ORP, pH, Alkalinity, Anions[c], Methane, Bromide, TOC	Perchlorate, DO, ORP, pH, Alkalinity, Anions[c], Methane, TOC	Perchlorate, DO, ORP, pH, Alkalinity, Anions[c], Methane, TOC	SOP No. 3-14	Performance data within the PRB; assessment of injection zone of influence
01-MW232	Groundwater	35	DO, ORP, pH, Bromide, TOC	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	SOP No. 3-14	Downgradient well to monitor effluent concentrations
01-MW233	Groundwater	45	DO, ORP, pH, Bromide, TOC	Perchlorate, DO, ORP, pH, Bromide	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	SOP No. 3-14	Downgradient well to monitor effluent concentrations
01-MW234	Groundwater	45	DO, ORP, pH, Bromide, TOC, Dissolved Metals	Perchlorate, DO, ORP, pH, Bromide, Dissolved Metals	Perchlorate, DO, ORP, pH, Dissolved Metals	Perchlorate, DO, ORP, pH, Dissolved Metals	SOP No. 3-14	Downgradient well to monitor effluent concentrations
01-PZ15	Groundwater	27.5	DO, ORP, pH, Bromide, TOC	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	SOP No. 3-14	Upgradient well for monitoring influent concentrations

Notes:

[a] The depth of the sample represents the middle of the screen interval of the monitoring well.

[b] To be conducted within 15 to 30 days of the completion of substrate injection

[c] Anions include nitrate and sulfate.

Table 18-5: Sampling Locations/IDs and Sample Analyses – ISB Performance Monitoring Plan for Station Boundary PRB at IRP Site 1

Sample Location/ ID Number	Matrix	Depth[a] (ft bgs)	Analytical Groups				Sampling SOP Reference	Rationale for Sampling Location
			First Month (Single Event)[b]	Year 1 (Quarterly)	Years 2 and 3 (Semi-Annually)	After Year 3 (Annually)		
02NEW16	Groundwater	45	DO, ORP, pH, Bromide, TOC	Perchlorate, VOCs[c],DO, ORP, pH	Perchlorate, VOCs[c],DO, ORP, pH	Perchlorate, VOCs[c],DO, ORP, pH	SOP No. 3-14	Upgradient well for monitoring influent concentrations
02-NEW36	Groundwater	80	DO, ORP, pH, Bromide, TOC	Perchlorate, VOCs[c],DO, ORP, pH	Perchlorate, VOCs[c],DO, ORP, pH	Perchlorate, VOCs[c],DO, ORP, pH	SOP No. 3-14	Upgradient well for monitoring influent concentrations
02-NEW37	Groundwater	80	DO, ORP, pH, Bromide, TOC	Perchlorate, VOCs[c],DO, ORP, pH, Alkalinity, Anions[d], Methane, Ethene, Ethane, Bromide, TOC	Perchlorate, VOCs[c],DO, ORP, pH, Alkalinity, Anions[d], Methane, Ethene, Ethane, TOC	Perchlorate, VOCs[c],DO, ORP, pH, Alkalinity, Anions[d], Methane, Ethene, Ethane, TOC	SOP No. 3-14	Performance data within the PRB; assessment of injection zone of influence
02-NEW38	Groundwater	80	DO, ORP, pH, Bromide, TOC	Perchlorate, VOCs[c],DO, ORP, pH, Anions[d], Methane, Ethene, Ethane, Bromide, TOC	Perchlorate, VOCs[c],DO, ORP, pH, Anions[d], Methane, Ethene, Ethane, TOC	Perchlorate, VOCs[c],DO, ORP, pH, Anions[d], Methane, Ethene, Ethane, TOC	SOP No. 3-14	Downgradient well to monitor effluent concentrations
02-NEW39	Groundwater	80	DO, ORP, pH, Bromide, TOC, Dissolved Metals	Perchlorate, VOCs[c],DO, ORP, pH, Dissolved Metals	Perchlorate, VOCs[c],DO, ORP, pH, Dissolved Metals	Perchlorate, VOCs[c],DO, ORP, pH, Dissolved Metals	SOP No. 3-14	Downgradient well to monitor effluent concentrations
02-NEW40	Groundwater	80	DO, ORP, pH, Bromide, TOC	Perchlorate, VOCs[c],DO, ORP, pH, Bromide	Perchlorate, VOCs[c],DO, ORP, pH	Perchlorate, VOCs[c],DO, ORP, pH	SOP No. 3-14	Downgradient well to monitor effluent concentrations

Notes:

[a] The depth of the sample represents the middle of the screen interval of the monitoring well.

[b] To be conducted within 15 to 30 days of the completion of substrate injection

[c] Analytes include COCs for IRP Site 2 groundwater (TCE, cis-1,2-DCE, PCE, 1,2-DCA, 1,1,2-TCA) and VC (generated due to reductive dechlorination of TCE and cis-1,2-DCE).

[d] Anions include nitrate and sulfate

Table 18-6: Sampling Locations/IDs and Sample Analyses – Groundwater Monitoring Plan for Overall Perchlorate Extent Monitoring

Sample Location/ ID Number	Matrix	Depth[a] (ft bgs)	Analytical Groups				Sampling SOP Reference	Rationale for Sampling Location
			Year 1 (First Event)[b]	Year 1 (Semi-annually)[c]	Year 1 through 3 (Semi-annually)[d]	After Year 3 (Annually)[e]		
01-MW101	Groundwater	133	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	Upgradient of Source Area
01-MW102	Groundwater	115	Perchlorate, DO, ORP, pH	---	---	---	SOP No. 3-14	Upgradient of Source Area
01-MW221	Groundwater	70	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	Upgradient of Source Area
01-PZ01	Groundwater	77.5	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	Upgradient of Source Area
01-PZ02	Groundwater	72.5	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	Upgradient of Source Area
01-PZ04	Groundwater	42.5	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	Upgradient of Source Area
01-PZ05	Groundwater	72.5	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	Upgradient of Source Area
01-PZ06	Groundwater	67.5	Perchlorate, DO, ORP, pH	---	---	---	SOP No. 3-14	Upgradient of Source Area
01-PZ12	Groundwater	82.5	Perchlorate, DO, ORP, pH	---	---	---	SOP No. 3-14	Upgradient of Source Area
01-MW204	Groundwater	39	---	---	Perchlorate, DO, ORP, pH	---	SOP No. 3-14	Source Area
01-MW208	Groundwater	42.5	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	Source Area
01-MW218	Groundwater	52.5	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	Source Area
01-MW220	Groundwater	105	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	Source Area
01-MW222	Groundwater	122.5	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	Source Area
01-PZ21B	Groundwater	60	---	---	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	SOP No. 3-14	Source Area
01-DGMW57	Groundwater	73	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	Intermediate Area[f]

Sample Location/ ID Number	Matrix	Depth[a] (ft bgs)	Analytical Groups				Sampling SOP Reference	Rationale for Sampling Location
			Year 1 (First Event)[b]	Year 1 (Semi-annually)[c]	Year 1 through 3 (Semi-annually)[d]	After Year 3 (Annually)[e]		
01-DGMW58	Groundwater	67	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	Intermediate Area[f]
01-MW206	Groundwater	32	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	Intermediate Area[f]
01-MW207	Groundwater	37.5	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	Intermediate Area[f]
01-MW211	Groundwater	55	---	---	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	SOP No. 3-14	Intermediate Area[f]
01-MW212	Groundwater	27.5	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	Intermediate Area[f]
01-MW213	Groundwater	32.5	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	Intermediate Area[f]
01-MW215	Groundwater	42.5	---	---	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	SOP No. 3-14	Intermediate Area[f]
01-MW216	Groundwater	32.5	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	Intermediate Area[f]
01-MW217	Groundwater	62.5	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	Intermediate Area[f]
01-MW223	Groundwater	52.5	---	---	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	SOP No. 3-14	Intermediate Area[f]
01-MW224	Groundwater	58	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	Intermediate Area[f]
01-PZ14	Groundwater	37.5	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	Intermediate Area[f]
01-PZ16	Groundwater	27.5	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	Intermediate Area[f]
02NEW11	Groundwater	55	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	Intermediate Area[f]
18BGMW24	Groundwater	50	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	Intermediate Area[f]
02_NEW02A	Groundwater	78.5	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	IRP Site 2 Area
02_NEW07A[g]	Groundwater	134.5	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	IRP Site 2 Area

Sample Location/ ID Number	Matrix	Depth[a] (ft bgs)	Analytical Groups				Sampling SOP Reference	Rationale for Sampling Location
			Year 1 (First Event)[b]	Year 1 (Semi-annually)[c]	Year 1 through 3 (Semi-annually)[d]	After Year 3 (Annually)[e]		
02-NEW08A	Groundwater	94	---	---	Perchlorate, DO, ORP, pH	---	SOP No. 3-14	IRP Site 2 Area
02NEW15	Groundwater	45	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	IRP Site 2 Area
02NEW16	Groundwater	45	---	---	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	SOP No. 3-14	IRP Site 2 Area
02NEW19	Groundwater	99.5	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	IRP Site 2 Area
02_NEW26A[g]	Groundwater	86.5	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	IRP Site 2 Area
02_NEW27A[g]	Groundwater	104.5	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	IRP Site 2 Area
02-NEW28A	Groundwater	70	---	---	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	SOP No. 3-14	IRP Site 2 Area
02NEW29	Groundwater	57	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	IRP Site 2 Area
02NEW30	Groundwater	75	---	---	Perchlorate, DO, ORP, pH	---	SOP No. 3-14	IRP Site 2 Area
02-NEW42[g]	Groundwater	80	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	IRP Site 2 Area
02PZ10	Groundwater	100	---	Perchlorate, DO, ORP, pH	---	---	SOP No. 3-14	IRP Site 2 Area
02PZ12	Groundwater	85	---	---	Perchlorate, DO, ORP, pH	Perchlorate, DO, ORP, pH	SOP No. 3-14	IRP Site 2 Area

Notes:
--- not applicable/not being sampled for that event.
[a] The depth of the sample represents the middle of the screen interval of the monitoring well.
[b] Proposed for wells that have been routine monitored at least once a year and for which perchlorate concentrations are reported to be less than its MCL form July 2004 to March 2011.
[c] Proposed for monitoring wells where perchlorate concentration have exceeded its MCL at least once in the past but for which latest available data (as of January 2013) show perchlorate less than its MCL.
[d] Proposed for monitoring wells where latest available data (as of January 2013) shows perchlorate concentration exceeding its MCL.
[e] Proposed for monitoring wells where latest available data (as of January 2013) shows perchlorate concentration exceeding its MCL. Monitoring Plan after year 3 will be revised appropriately based on the evaluation of results from Years 1 through 3.
[f] Intermediate Area is the area downgradient of Source area and up to IRP Site 2.
[g] The need for continued groundwater sampling and analysis for perchlorate after Year 1 for wells 02NEW07A, 02NEW26A, 02NEW27A, and 02NEW42 will be evaluated following comprehensive review of PRB performance data and perchlorate distribution data near the Station Boundary.

Table 18-7: Sampling Locations/IDs and Sample Analyses – Sampling and Analysis Schedule for IRP Site 2 MNA

Sample Location/ ID Number	Matrix	Depth[a] (ft bgs)	Analytical Groups			Sampling SOP Reference	Rationale for Sampling Location
			Year 1 through 3 (Annually)	Year 1 through 3 (Semi-annually)	After Year 3 (Annually)		
02_NEW02A	Groundwater	78.5	VOCs[b], DO, ORP, pH	---	VOCs[b], DO, ORP, pH	SOP No. 3-14	Define extent of TCE exceeding its RG to the southeast
02_NEW07A	Groundwater	134.5	VOCs[b], DO, ORP, pH	---	VOCs[b], DO, ORP, pH	SOP No. 3-14	Define downgradient extent of TCE plume
02-NEW08A	Groundwater	94	VOCs[b], DO, ORP, pH	---	VOCs[b], DO, ORP, pH	SOP No. 3-14	Verify that PCE concentrations are less than its RG
02-NEW19	Groundwater	99.5	---	VOCs[b], DO, ORP, pH	VOCs[b], DO, ORP, pH	SOP No. 3-14	TCE concentrations and extent to the northwest
02_NEW26A	Groundwater	85.5	---	VOCs[b], DO, ORP, pH	VOCs[b], DO, ORP, pH	SOP No. 3-14	Define extent of TCE exceeding its RG to the southeast
02_NEW27A	Groundwater	104.5	VOCs[b], DO, ORP, pH	---	VOCs[b], DO, ORP, pH	SOP No. 3-14	Define downgradient extent of TCE plume
02-NEW28A	Groundwater	70	---	VOCs[b], DO, ORP, pH	VOCs[b], DO, ORP, pH	SOP No. 3-14	TCE concentrations near the former Station Boundary
02-NEW29	Groundwater	57	---	VOCs[b], DO, ORP, pH	VOCs[b], DO, ORP, pH	SOP No. 3-14	TCE concentrations in the central portion of the plume
02-NEW41	Groundwater	70	VOCs[b], DO, ORP, pH	---	VOCs[b], DO, ORP, pH	SOP No. 3-14	Define TCE concentrations exceeding its RG upgradient of well 02-NEW29
02-NEW42	Groundwater	80	VOCs[b], DO, ORP, pH	---	VOCs[b], DO, ORP, pH	SOP No. 3-14	Define TCE concentrations and extent to the west/northwest
02-PZ05	Groundwater	90	VOCs[b], DO, ORP, pH	---	VOCs[b], DO, ORP, pH	SOP No. 3-14	Define extent of TCE exceeding its RG to the northwest

Notes:
--- not applicable/not being sampled for that event.

[a] The depth of the sample represents the middle of the screen interval of the monitoring well
[b] Analytes include COCs for IRP Site 2 groundwater (TCE, cis-1,2-DCE, PCE, 1,2-DCA, 1,1,2-TCA).

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SAP Worksheet #19: Field Sampling Requirements Table

Matrix	Analytical Group	Analytical and Preparation Method / SOP Reference	Containers (number, size, and type)	Sample Volume (units)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time[1] (preparation / analysis)
Groundwater	TOC	EPA 415/EMAX-415.1	125ml Plastic	125 ml	Cool ≤ 6°C, HCl to pH <2	28 days[a]
Groundwater	Dissolved Metals	EPA 6020&7470A/EMAX-6020&EMAX-7470	250ml Poly Plastic	250 ml	Cool to ≤ 6°C , HNO_3 to pH <2.	6 months, 28 days for mercury
Groundwater	Alkalinity	EPA 310.1/EMAX-310.1	500ml Plastic	125 ml	Cool ≤ 6°C,	14 days[a]
Groundwater	Anions, Bromide	EPA 300/EMAX-300.0		125 ml	Cool ≤ 6°C,	48 Hours (Nitrate)/ 28 days[a]
Groundwater	Perchlorate	EPA314*/EMAX-314.0		125 ml	Cool ≤ 6°C,	28 days[a]
Groundwater	Anions, Bromide	EPA 300/EMAX-300.0	One 16-ounce glass jar or stainless-steel liner with Teflon®-lined lid/end caps	250 mL plastic	Cool 4°±2°C,	28 days[a]
Groundwater	Metabolic gases	RSK 175/EMAX-RSK175	3x40ml VOA vial	40-ml	Cool, ≤ 6°C, HCl to pH<2, with minimum headspace.	14 days[a]
Groundwater	VOCs	EPA 8260B/EMAX-8260	3x40ml VOA vial	40-ml	Cool, ≤ 6°C, HCl to pH<2, with minimum headspace.	14 days[a]

Notes:
*U.S. EPA Method 314 has previously been used at IRP Sites 1 and 2 and results have been compared with those obtained using Liquid Chromatography/Mass Spectrometer (LC/MS) Method 331 and Ion Chromatography/Mass Spectrometer (IC/MS) Method 332. The comparisons of the U.S. EPA Method 314 to LC/MS Method 331 and IC/MS Method 332 results have indicated that U.S. EPA Method 314 is yielding precise, accurate, and usable results. Therefore, U.S. EPA Method 314 will be used for continued groundwater monitoring at IRP Sites 1 and 2.

[1]Maximum holding time is calculated from the time the sample is collected to the time the sample is prepared/ extracted.
[a] From sample collection to analysis
[b] From sample collection to extraction
[c] From sample extraction to analysis

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SAP Worksheet #20: Field Quality Control Sample Summary Table

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates	No. of MS/MSDs[b]	No. of Field Blanks	No. of Equip. Blanks	No. of VOC Trip Blanks[e]	No. of PT Samples	Total No. of Samples to Lab
Year 1 Groundwater Sampling[a]									
Perchlorate	EPA 314	296	30	na	1[c]	1[d]	0	0	326
Anions/Tracers	EPA 300	155	16	na	0	0	0	0	171
Alkalinity	EPA 310.1	32	3	na	0	0	0	0	35
TOC	EPA 415	85	8	na	0	0	0	0	93
Metabolic Gases	RSK 175	52	5	na	0	0	0	0	57
VOCs	EPA 8260	39	5	na	1[c]	1[d]	4	0	48
Dissolved Metals	EPA 6020	15	2	na	0	0	0	0	17
Years 2 and 3 – Semi-Annual Groundwater Sampling									
Perchlorate	EPA 314	150	15	na	1[c]	1[d]	0	0	165
Anions/Tracers	EPA 300	52	5	na	0	0	0	0	57
Alkalinity	EPA 310.1	32	3	na	0	0	0	0	35
TOC	EPA 415	52	5	na	0	0	0	0	57
Metabolic Gases	RSK 175	52	5	na	0	0	0	0	57
VOCs	EPA 8260	54	5	na	1[c]	1[d]	5	0	64
Dissolved Metals	EPA 6020	6	1	na	0	0	0	0	7
After Year 3 – Annual Groundwater Sampling									

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates	No. of MS/MSDs[b]	No. of Field Blanks	No. of Equip. Blanks	No. of VOC Trip Blanks[e]	No. of PT Samples	Total No. of Samples to Lab
Perchlorate	EPA 314	41	4	na	1[c]	1[d]	0	0	45
Anions/Tracers	EPA 300	13	1	na	0	0	0	0	14
Alkalinity	EPA 310.1	8	1	na	0	0	0	0	9
TOC	EPA 415	13	1	na	0	0	0	0	14
Metabolic Gases	RSK 175	13	1	na	0	0	0	0	4
VOCs	EPA 8260	11	1	na	1[c]	1[d]	1	0	13
Dissolved Metals	EPA 6020	3	1	na	0	0	0	0	4

Notes:

[a] Includes all the groundwater sampling conducted within the first year including the baseline and quarterly sampling.

[b] - not applicable - sufficient sample is routinely collected for laboratory quality control measurements.

[c] 1 per lot of de-ionized water used for equipment rinsate collection

[d] one per day.

[e] – one per cooler containing VOC samples.

SAP Worksheet #21: Project Sampling SOP References Table

Reference Number	Title, Revision Date and / or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Y/N)	Comments
Worksheet #17	Not applicable	AEJV	Not applicable	Y	Sampling procedures are described in Worksheet #17.
Worksheet #27	Sample Chain of Custody	AEJV	Not applicable	Y	Sampling procedures are described in Worksheet #27.
Worksheet #27	Sample Collection, Packaging, Labeling	AEJV	Not applicable	Y	Sampling procedures are described in Worksheet #27.
3-12	Monitoring/Injection Well Drilling, Installation and Destruction, 3/2012	AEJV		Y	
3-14	Groundwater Monitoring, 3/2012	AEJV	Not applicable	Y	
3-06	Equipment Decontamination, 3/2012	AEJV	Not applicable	Y	
3-13	Amendment Injection Procedures, 3/2012	AEJV		Y	

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SAP Worksheet #22: Field Equipment Calibration, Maintenance, Testing, and Inspection Table

Field Equipment	Calibration Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference	Comments
Temperature	Initial calibration	Beginning of field mobilization	± 1°C	Recalibrate or repair	Field team leader	SOP No. 3-14	
	Continuing calibration	Daily (beginning of field day)	± 1°C	Recalibrate or repair	Field team leader	SOP No. 3-14	
pH	Initial calibration	Daily (beginning of field day)	± 0.5 units	Recalibrate or repair	Field team leader	SOP No. 3-14	
	Continuing calibration	> 1hour between meter use	± 0.5	Recalibrate or repair	Field team leader	SOP No. 3-14	
	Final calibration	Daily (end of field day)	± 0.5 units	Record	Field team leader	SOP No. 3-14	
Turbidity	Initial calibration	Daily (beginning of field day)	± 10%	Recalibrate or repair	Field team leader	SOP No. 3-14	
	Final calibration	Daily (end of field day)	± 10%	Record	Field team leader	SOP No. 3-14	
Dissolved oxygen	Initial calibration	Daily (beginning of field day)	±0.5 mg/L	Recalibrate or repair	Field team leader	SOP No. 3-14	
	Continuing calibration	> 1hour between meter use	±0.5 mg/L	Recalibrate or repair	Field team leader	SOP No. 3-14	
	Final calibration	Daily (end of field day)	±0.5 mg/L	Record	Field team leader	SOP No. 3-14	
Oxidation-reduction potential	Initial calibration	Daily (beginning of field day)	±50 mV	Recalibrate or repair	Field team leader	SOP No. 3-14	
	Continuing calibration	> 1hour between meter use	±50 mV	Recalibrate or repair	Field team leader	SOP No. 3-14	
	Final calibration	Daily (end of field day)	±50 mV	Record	Field team leader	SOP No. 3-14	
Water Level Indicator	Water Level	Pre-calibrated tape			Field team leader	SOP No. 3-14	

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SAP Worksheet #23: Analytical SOP References Table

Lab SOP Number	Title, Revision Date, and / or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work? (Y/N)
EMAX-415.1	Total Organic Carbon, Revision 3	Definitive	Total Organic Carbon	Chemical oxidation	EMAX	N
EMAX-310.1	Alkalinity, Revision 5	Definitive	Alkalinity	Titration	EMAX	N
EMAX-300.0	Ion Chromatography Analysis, Revision 7	Definitive	Anions, Bromide	Ion Chromatography	EMAX	N
EMAX-RSK175	Dissolved Gases, Revision 2	Definitive	Metabolic gases	Gas chromatography, flame ionization detector	EMAX	N
EMAX-8260	Volatile Organic Compounds By Gc/Ms, Revision 8	Definitive	VOCs	Gas chromatograph/mass spectrometry	EMAX	N
EMAX-314.0	Perchlorate By Ion Chromatography Analysis, Revision 4	Definitive	Perchlorate	Ion Chromatography	EMAX	N
EMAX-6020	Trace Metals by ICP-MS, Revision 8	Definitive	Metals	ICP-MS	EMAX	N
EMAX-7470	Mercury by Cold Vapor Absorption, Revision 7	Definitive	Mercury	Cold Vapor Atomic Absorption	EMAX	N

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SAP Worksheet #24: Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
GCMS	ICAL	Initially; as needed	SPCCs average RF ± 0.050 and %RSD for RFs for CCCs < 30% and one option below 1). linear- mean RSD for all analytes =/<15% 2). linear – least squares regression r =/> 0.995, when RSD >15% 3). non-linear – COD > 0.990(6 points shall be used for second order, 7 points shall be used for third	Locate the source of the problem. If expected RFs are not met, check for standard degradation or perform instrument adjustment and/or maintenance to correct the problem then repeat initial calibration	EMAX Analyst	EMAX-8260
GCMS	ICV	Every after ICAL	Value of second source for all project analytes within ±20% of expected value (initial source) except for the following compounds due to erratic chromatographic behavior: bromomethane, chloroethane, chloromethane, dichlorodifluoromethane within +/- 35% of expected value.	Prepare fresh standard and re-analyze ICV to rule out standard degradation or inaccurate injection. If problem persist perform instrument adjustment and/or maintenance to correct the problem and repeat ICAL and ICV.	EMAX Analyst	EMAX-8260
GCMS	CCV	Every 12 hrs.	1. Average RF for SPCCs: VOCs ≥ 0.30 for chlorobenzene and 1,1,2,2-tetrachloroethane, and ≥ 0.1 for chloromethane, bromoform, and 1,1-dichloroethene. 2. %Difference/Drift for CCCs and target compounds ± 20%D (Note: D = difference when using RFs or drift when using least	Prepare fresh standard and re-analyze CCV to rule out standard degradation or inaccurate injection. If problem persist perform instrument adjustment and/or maintenance to correct the problem and repeat ICAL.	EMAX Analyst	EMAX-8260

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
			squares regression or non-linear calibration.) except for the following compounds due to erratic chromatographic behavior: bromomethane, chloroethane, chloromethane, dichlorodifluoromethane within +/- 30% of expected value (unless they are project analytes of interest)			
GC-RSK175	ICAL	Initially; as needed	1) RSD for all analytes ≤20% 2) linear – least squares regression r > 0.995 3) non-linear – COD > 0.990 (6 points shall be used for second order, 7 points shall be used for third order)	Locate the source of the problem. If expected RSD is not met, check for standard degradation or perform instrument adjustment and/or maintenance to correct the problem then repeat initial calibration	EMAX-Analyst	EMAX-RSK175
GC-RSK175	ICV	Every after ICAL	All project analytes within established retention time windows. RSK175 Methods: All project analytes within ±25% of expected value from ICAL.	Prepare fresh standard and re-analyze ICV to rule out standard degradation or inaccurate injection. If problem persist perform instrument adjustment and/or maintenance to correct the problem and repeat ICAL.	EMAX-Analyst	EMAX-RSK175
GC-RSK175	CCV	Every 12 hrs	All project analytes within established retention time windows. RSK175 Methods: All project analytes within ±25% of expected value from ICAL. value	Prepare fresh standard and re-analyze CCV to rule out standard degradation or inaccurate injection. If problem persist perform instrument adjustment and/or maintenance to correct the problem and repeat ICAL.	EMAX-Analyst	EMAX-RSK175
IC	ICAL	Initially; as needed	1) RSD for all analytes ≤20%	Locate the source of the problem. If expected RSD is not	EMAX-Analyst	EMAX-

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
			2) linear – least squares regression r > 0.995 3) non-linear – COD > 0.990 (6 points shall be used for second order, 7 points shall be used for third order)	met, check for standard degradation or perform instrument adjustment and/or maintenance to correct the problem then repeat initial calibration		300.0 EMAX-314.0
IC	ICV	Every after ICAL	All project analytes within established retention time windows. HPLC / IC Methods: All project analytes within ±15% of expected value from ICAL.	Prepare fresh standard and re-analyze ICV to rule out standard degradation or inaccurate injection. If problem persist perform instrument adjustment and/or maintenance to correct the problem and repeat ICAL.	EMAX-Analyst	EMAX-300.0 EMAX-314.0
IC	CCV	Daily, before sample analysis, after every 10 field samples, and at the end of analysis sequence.	HPLC / IC Methods: All project analytes within ±15% of expected value from ICAL.	Prepare fresh standard and re-analyze CCV to rule out standard degradation or inaccurate injection. If problem persist perform instrument adjustment and/or maintenance to correct the problem and repeat ICAL.	EMAX-Analyst	EMAX-300.0 EMAX-314.0
TOC	ICAL	Prior to sample analysis	Correlation Coefficient (r^2) $\geq$0.995	Locate the source of the problem. If outliers exist, prepare fresh calibration standards and repeat ICAL.	EMAX-Analyst	EMAX-415.1
TOC	ICV	Every after ICAL	All project analytes within established retention time windows. HPLC / IC Methods: All project analytes within ±15% of expected value from ICAL.	Prepare fresh standard and re-analyze ICV to rule out standard degradation or inaccurate injection. If problem persist perform instrument adjustment and/or maintenance to correct	EMAX-Analyst	EMAX-415.1

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
				the problem and repeat ICAL.		
TOC	CCV	Daily, before sample analysis, after every 15 field samples, and at the end of analysis sequence.	All project analytes within ±10% of expected value from ICAL.	Prepare fresh standard and re-analyze CCV to rule out standard degradation or inaccurate injection. If problem persist perform instrument adjustment and/or maintenance to correct the problem and repeat ICAL.	EMAX-Analyst	EMAX-415.1
Titration	Standard Check	Daily before sample analysis	All analytes within ± 10% of expected value	Discard the standard and use a new standard lot.	EMAX-Analyst	EMAX-310.1
ICP/ICPMS	Initial Calibration (ICAL)	Daily	If more than one calibration standard is used, r ≥ 0.995	Locate the source of the problem. Check for standard degradation or perform instrument adjustment and/or maintenance to correct the problem and then repeat initial Calibration	Analyst	EMAX-6020 DOD QSM
ICP/ICPMS	Low Level Calibration Check Standard	Once after each initial calibration	Value of all project analytes within 20% of true value.	Diagnose the problem. Prepare fresh standard and re-analyze to rule out standard degradation or inaccurate injection. If problem persist perform instrument adjustment and/or maintenance to correct the problem and repeat ICAL.	Analyst	EMAX-6020 DOD QSM
ICP/ICPMS	ICV	Once after each initial calibration	Value of all project analytes within 10% of true value.	Prepare fresh standard and re-analyze ICV to rule out standard degradation or inaccurate injection. If problem persist perform instrument adjustment	Analyst	EMAX-6020 DOD QSM

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
				and/or maintenance to correct the problem and repeat ICAL.		
ICP/ICPMS	Continuing Calibration Verification	After every 10 field samples, and at the end of analysis sequence.	Value of all project analytes within 10% of true value.	Diagnose problem. Prepare fresh standard and re-analyze CCV to rule out standard degradation or inaccurate injection. If problem persist perform instrument adjustment and/or maintenance to correct the problem. Reanalyse all samples since last successful CCV. If problem persists, repeat ICAL.	Analyst	EMAX-6020 DOD QSM
CVAA	Initial Calibration (ICAL)	Daily	r ≥ 0.995	Locate the source of the problem. Check for standard degradation or perform instrument adjustment and/or maintenance to correct the problem and then repeat initial Calibration	Analyst	EMAX-7470 EMAX-7471 DOD QSM
CVAA	ICV	Once after each initial calibration	Value of all project analytes within 10% of true value.	Prepare fresh standard and re-analyze ICV to rule out standard degradation or inaccurate injection. If problem persist perform instrument adjustment and/or maintenance to correct the problem and repeat ICAL.	Analyst	EMAX-7470 DOD QSM
CVAA	Continuing Calibration Verification	After every 10 field samples, and at the end of analysis	Value of all project analytes within 20% of true value.	Prepare fresh standard and re-analyze ICV to rule out standard degradation or inaccurate injection. If problem persist perform instrument adjustment and/or maintenance to correct	Analyst	EMAX-7470 DOD QSM

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
		sequence.		the problem and repeat ICAL.		

Notes:

CA	corrective action	RSD	relative standard deviation
CCC	calibration check compound	SPCC	system performance check compound
CCV	continuing calibration verification		
CVAA	cold vapor atomic absorption		
DoD	Department of Defense		
GC	gas chromatograph		
ICAL	initial calibration		
ICP	inductively coupled plasma		
ICV	initial calibration verification		
MDL	method detection limit		
MS	mass spectrometer		
QSM	quality systems manual		
RF	response factors		

SAP Worksheet #25: Analytical Instrument and Equipment, Maintenance, Testing, and Inspection Table

Instrument / Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
GCMS GC	Parameter Setup	Physical check	Physical check	Initially; prior to DCC	Predetermined optimum parameter settings	Reset if incorrect	EMAX Analyst	EMAX-8260 EMAX-RSK175 EMAX-300.0 EMAX-315.0 EMAX-415.1
GCMS	Tune Check	Instrument Performance	Conformance to instrument tuning.	Initially; prior to DCC	Compliance to ion abundance criteria	Repeat tune check to rule out standard degradation or inaccurate injection. If problem persist perform retune the instrument and repeat tune check.	EMAX Analyst	EMAX-8260
IC	Daily Check	Physical check	Examples: Check pump for leaks and spills. Check all air lines for crimping or discoloration. Empty waste container if needed. Detector maintenance – inspect flow cell for leaks.	Daily, prior to use.	No physical defects and performance checks within limits.	Examples: Isolate and repair leaks. Relocate pinched lines and replace damaged lines.	EMAX-Analyst	EMAX-300.0 EMAX-314.0

Instrument / Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
ICPMS	Parameter Setup	Physical check	Check that the autosampler is functioning as expected Check pump rate Check nebulizer gas flow Check rinse bottle	Initially; prior to each use	Autosampler must move to the expected position when activated. Pump rate: 0.08 – 0.12 rps Nebulizer gas flow: 1.05-1.25 L/min Rinse bottle: Filled to mark	Reset autosampler if problem persist perform autosampler troubleshooting prior to instrument use. Adjust pump rate if necessary otherwise perform pump trouble-shooting. Adjust if gas flow as needed otherwise perform instrument troubleshooting. Fill rinse bottle to mark.	EMAX Chemist	EMAX-6020
ICPMS	Tune Check	Instrument Performance	Conformance to instrument tuning.	Initially; prior to DCC	Compliance to ion abundance criteria as specified by the method.	Repeat tune check to rule out standard degradation or inaccurate injection. If problem persist perform retune the instrument and repeat tune check.	EMAX Chemist	EMAX-6020

Instrument / Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
ICPMS	ICS/ICSA	Instrument Performance	Conformance to interference check	Prior to sample analysis	**ICS-A:** Absolute value of concentration for all non-spiked analytes < LOD (unless they are a verified impurity from a spiked analyte.)Within **ICS-AB** ± 20% of expected value	Terminate analysis, reanalyze ICS to rule out standard degration or inaccurate injection. If problem persist, perform instrument maintenance, repeat calibrations and reanalyze all associated samples.	EMAX Chemist	EMAX-6020
ICPMS	ICB/CCB	Instrument Performance	Instrument contamination check	After every calibration Verification – Before samples, after every 10, and at the end of sequence.	No analytes detected ≥ LOD	Determine possible source of contamination and apply appropriate measure to correct the problem. Reanalyze calibration blank and all associated samples.	EMAX Chemist	EMAX-6020

Instrument / Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Cold Vapor	ICB/CCB	Instrument Performance	Instrument contamination check	After every calibration Verification – Before samples, after every 10, and at the end of sequence.	No analytes detected ≥ LOD	Determine possible source of contamination and apply appropriate measure to correct the problem. Reanalyze calibration blank and all associated samples.	EMAX Chemist	EMAX-7470 EMAX-7471

SAP Worksheet #26: Sample Handling System

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
Sample Collection (Personnel/Organization): Field Technician / AEJV
Sample Packaging (Personnel/Organization): Field Technician / AEJV
Coordination of Shipment (Personnel/Organization): Project Chemist / AEJV
Type of Shipment/Carrier: Laboratory courier or commercial carrier
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): Analytical Laboratory, EMAX
Sample Custody and Storage (Personnel/Organization): Analytical Laboratory, EMAX
Sample Preparation (Personnel/Organization): Analytical Laboratory, EMAX
Sample Determinative Analysis (Personnel/Organization): Various chemists and technicians, Analytical Laboratory, EMAX
SAMPLE ARCHIVING
Field Sample Storage (No. of days from sample collection): None
Sample Extract/Digestate Storage (No. of days from extraction/digestion): 120 Days
Biological Sample Storage (No. of days from sample collection): Not applicable
SAMPLE DISPOSAL
Personnel/Organization: Analytical Laboratory, EMAX
Number of Days from Analysis: 6 months and 1 day[1]

Notes:

[1]Samples will not be disposed of until specifically approved by the Navy.

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SAP Worksheet #27: Sample Custody Requirements

27.1 SAMPLE NUMBER

All samples submitted to an analytical laboratory will be uniquely numbered according to the following formats.

27.1.1 Groundwater Samples

Groundwater samples will be uniquely numbered as "ZMWx-mmddyy" where

- z = IRP Site Number
- MWx = well identification
- mmddyy = sample date (062508 for June 25, 2008)

For example, a groundwater sample collected from IRP Site 1 monitoring well MW-12 on June 25, 2012 would be labeled as (1MW12-062512).

27.1.2 QC Samples

Quality control (QC) samples will be uniquely numbered as follows.

27.1.3 Equipment Rinsate

Equipment rinsate samples will be uniquely numbered as "zER-(collection date)" where

- z = IRP Site Number
- ER = equipment rinsate sample
- collection date = date of collection as MO/DY/YR

For example, 01ER-120112 refers to an equipment rinsate at IRP Site 1 on December 1, 2012.

27.1.4 Source Blank (associated with equipment rinsate samples)

Source blank samples will be uniquely numbered as "zSB-(collection date)" where

- z = IRP Site Number
- SB = source blank sample
- collection date = date of collection as MO/DY/YR

For example, 01SB-110112 refers to a source blank collected at IRP Site 1 on November 1, 2012.

27.1.5 Matrix Spike / Matrix Spike Duplicate

Matrix Spike (MS)/Matrix Spike Duplicate (MSD) samples will be identified during the field sampling activities. Field sampling personnel will denote the MS/MSD samples by writing "MS/MSD" in the comments column on the chain-of-custody (COC) form.

The sample number will be recorded in the field logbook and on the labels and COC form at the time of sample collection. A complete description of the sample and sampling conditions will be recorded in the field logbook and referenced using the unique sample identification number.

27.2 SAMPLE LABELING

Sample labels are necessary to prevent misidentification of samples. Sample labels will be filled out in indelible ink and affixed to sample containers at the time of sample collection. Each sample label will be covered with clear tape. Each sample container will be labeled with the following, at a minimum:

- Company name
- Sample identification number
- Sample collection date (month/day/year)
- Time of collection (24-hour clock)
- Sampler's initials
- Analyses required
- Preservative (if any)

27.3 SAMPLE HANDLING AND SHIPPING

Immediately after samples are collected and labeled, each sample will be placed in resealable plastic bags and then placed into a sample cooler containing ice. All glass sample containers will be protected with bubble wrap to minimize the chance of breakage.

Sampling will be shipped to the laboratory either by using a laboratory provided courier and commercial carrier.

27.4 FIELD DOCUMENTATION

In order to maintain the integrity and traceability of samples, all information pertinent to field sampling will be recorded in a field logbook. All samples will be properly labeled and custody sealed prior to being transported to the laboratory and will be accompanied by completed COC documentation. All documentation will be recorded in a field logbook in indelible ink.

27.5 CHAIN-OF-CUSTODY

To establish the documentation necessary to trace sample possession from the time of collection through analysis and disposal, a COC record will be completely filled out and will accompany every sample. Samples will be delivered to the laboratory for analysis as soon as practicable. A COC record will accompany all samples.

The following will be recorded on the COC record:

- Project name
- Project location
- Project number
- Sample identification (ID)
- Sampler name
- Sampler signature
- Project contact

- Airbill number (if applicable)
- Date of sample collection
- Time of sample collection to the nearest minute, 24-hour clock
- Sample type (matrix)
- Turnaround time
- Sample depth in feet (start, end)
- Laboratory name
- Number of sample containers
- Analyses required
- Comments
- MS/MSD samples
- Observations specific to sample
- Field filtered
- Transfer signature to relinquish samples
- The sampler will be the first person to relinquish sample possession
- Courier/laboratory representative signature (for commercial carrier, record airbill number here [if applicable])
- Date/time (of custody transfer)
- Laboratory instruction
- Data package requirement (Level III or IV)

27.6 FIELD LOGBOOKS

A permanently bound field logbook with consecutively numbered pages, used for sampling activities only, will be assigned to this project. All entries will be recorded in indelible ink. At the end of each workday, the logbook pages will be signed by the responsible sampler, and any unused portions of the logbook pages will be crossed out, signed, and dated.

If it is necessary to transfer the logbook to another person, the person relinquishing the logbook will sign and date the last page used, and the person receiving the logbook will sign and date the next page to be used.

At a minimum, the logbook will contain the following information:

- Project name and location
- Date and time
- Personnel in attendance
- General weather information
- Work performed
- Field observations
- Sampling performed, including specifics such as location, type of sample, type of analyses, and sample identification

- Field analyses performed, including results, instrument checks, problems, and calibration records for field instruments
- Descriptions of deviations from this SAP
- Problems encountered and corrective action taken
- Identification of field QC samples
- QC activities
- Verbal or written instructions
- Any other events that may affect the samples

27.7 DOCUMENT CORRECTIONS

Changes or corrections on any project documentation will be made by crossing out the erroneous item with a single line and initialing (by the person performing the correction) and dating the correction. The original item, although erroneous, must remain legible beneath the cross-out line. The new information should be written clearly above the crossed-out item.

Chain of Custody Record

Laboratory:
Contact:
Client:

Shipment Number:
Method of Shipment:
Air Bill Number:
Cooler Number:
Custody Seal No:
Project Number:
Project Name:
Project Contact:
Samplers Signature:

Lab Job:
Ship Date:
Page:

Sample	Field Sample ID	Sampling Date	Sampling Time	Matrix Type	Type/Size of Container	Preservation Temp.	Preservation Chemical	Filtered	No. of Containers	Analysis Requested															Remarks

Relinquished By	Date / Time	Relinquished By	Date / Time	Relinquished By	Date / Time	Received By	Date / Time
Signature:		Signature:		Signature:		Signature:	
Printed:		Printed:		Printed:		Printed:	
Company:		Company:		Company:		Company:	
Reason:				Reason:			

Comments:	Relinquished By	Date / Time	Received By	Date / Time
	Signature:		Signature:	
	Printed:		Printed:	
	Company:		Company:	
	Reason:			

Distribution: WHITE to Analytical Laboratory Report, YELLOW to Laboratory File, PINK to Courier/Delivery Service or Field Office, GOLDEN to Project Office File

Label

Company Name

Site Name

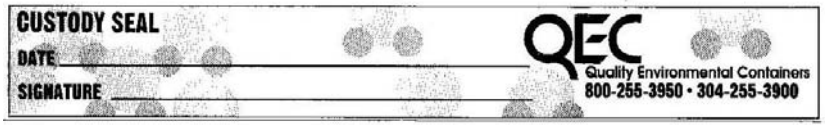
Contract No.:

Task Order No.:

Sampler:

Sample Date: Time:

Custody Seal



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SAP Worksheet #28: Laboratory QC Samples

Matrix: **Groundwater**

Analytical Group: **VOCs**

Analytical Method / SOP Reference: **8260B** **EMAX-8260**

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per preparation batch	All analytes <1/2 QLs, except for common lab contaminants, wherein the standard is < QL	Re-prep and reanalyze LCS and all samples processed with the non-conforming LCS.	Analytical Laboratory Chemist	Accuracy/Bias - Contamination	All analytes <1/2 QLs
Surrogate	Every analytical sample	Refer to QC Limit Table, as per DOD QSM	Re-prep and reanalyze LCS and all samples processed with the non-conforming LCS.	Analytical Laboratory Chemist	Accuracy/Bias	Refer to QC Limit Table
LCS	One per sample preparation batch	Refer to QC Limit Table as per DOD QSM	Re-prep and reanalyze LCS and all samples processed with the non-conforming LCS.	Analytical Laboratory Chemist	Accuracy/Bias	Refer to QC Limit Table
MS/MSD	Project designated sample matrix QC.	Refer to QC Limit Table	If result is indicative of matrix interference, discuss in case narrative. Otherwise check for possible source of error, and extract / reanalyze the sample.	Analytical Laboratory Chemist	Interferences - Accuracy/Bias - Precision	Refer to QC Limit Table

Matrix: **Groundwater**

Analytical Group: **Dissolved Gases**

Analytical Method / SOP Reference: **RSK175**
EMAX-RSK175

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per preparation batch	All analytes <1/2 QLs, except for common lab contaminants, wherein the standard is < QL	Re-prep and reanalyze LCS and all samples processed with the non-conforming LCS.	Analytical Laboratory Chemist	Accuracy/Bias - Contamination	All analytes <1/2 QLs
LCS	One per sample preparation batch	Witihin 70-140%	Re-prep and reanalyze LCS and all samples processed with the non-conforming LCS.	Analytical Laboratory Chemist	Accuracy/Bias	Witihin 70-140%
MS/MSD	Project designated sample matrix QC.	Within 60-140 RPD: ± 30%	If result is indicative of matrix interference, discuss in case narrative. Otherwise check for possible source of error, and extract / reanalyze the sample.	Analytical Laboratory Chemist	Interferences - Accuracy/Bias - Precision	Within 60-140 RPD: ± 30%

Matrix: **Groundwater**

Analytical Group: **Perchlorate**

Analytical Method / SOP Reference: **EPA 314.0**
EMAX-314.0

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per preparation batch	All analytes <1/2 QLs, except for common lab contaminants, wherein the standard is < QL	Re-prep and reanalyze LCS and all samples processed with the non-conforming LCS.	Analytical Laboratory Chemist	Accuracy/Bias - Contamination	All analytes <1/2 QLs
LCS	One per sample preparation batch	Witihin 80-120%	Re-prep and reanalyze LCS and all samples processed with the non-conforming LCS.	Analytical Laboratory Chemist	Accuracy/Bias	Witihin 80-120%
MS/MSD	Project designated sample matrix QC.	Within 80-120 RPD: ± 20%	If result is indicative of matrix interference, discuss in case narrative. Otherwise check for possible source of error, and extract / reanalyze the sample.	Analytical Laboratory Chemist	Interferences - Accuracy/Bias - Precision	Within 80-120 RPD: ± 20%
Duplicate	Project designated sample matrix QC.	RPD: ± 20%	If result is indicative of matrix interference, discuss in case narrative. Otherwise check for possible source of error, and extract / reanalyze the sample.	Analytical Laboratory Chemist	Interferences - Accuracy/Bias - Precision	RPD: ± 20%

Matrix: **Groundwater**

Analytical Group: **Anions (Nitrate/Sulfate/Bromide)**

Analytical Method / SOP Reference: **EPA 300.0**
EMAX-300.0

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per preparation batch	All analytes <1/2 QLs, except for common lab contaminants, wherein the standard is < QL	Re-prep and reanalyze LCS and all samples processed with the non-conforming LCS.	Analytical Laboratory Chemist	Accuracy/Bias - Contamination	All analytes <1/2 QLs
LCS	One per sample preparation batch	Witihin 80-120%	Re-prep and reanalyze LCS and all samples processed with the non-conforming LCS.	Analytical Laboratory Chemist	Accuracy/Bias	Witihin 80-120%
MS/MSD	Project designated sample matrix QC.	Within 75-125 RPD: ± 20%	If result is indicative of matrix interference, discuss in case narrative. Otherwise check for possible source of error, and reanalyze the sample.	Analytical Laboratory Chemist	Interferences - Accuracy/Bias - Precision	Within 75-125 RPD: ± 20%
Duplicate	Project designated sample matrix QC.	RPD: ± 20%	If result is indicative of matrix interference, discuss in case narrative. Otherwise check for possible source of error, and reanalyze the sample.	Analytical Laboratory Chemist	Interferences - Accuracy/Bias – Precision	RPD: ± 20%

:

Matrix: **Groundwater**

Analytical Group: **Total Organic Carbon**

Analytical Method / SOP Reference: **EPA 415.1**
EMAX-415.1

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per preparation batch	All analytes <1/2 QLs, except for common lab contaminants, wherein the standard is < QL	Re-prep and reanalyze LCS and all samples processed with the non-conforming LCS.	Analytical Laboratory Chemist	Accuracy/Bias - Contamination	All analytes <1/2 QLs
LCS	One per sample preparation batch	Witihin 80-120%	Re-prep and reanalyze LCS and all samples processed with the non-conforming LCS.	Analytical Laboratory Chemist	Accuracy/Bias	Witihin 80-120%
MS/MSD	Project designated sample matrix QC.	Within 75-125 RPD: ± 20%	If result is indicative of matrix interference, discuss in case narrative. Otherwise check for possible source of error, and reanalyze the sample.	Analytical Laboratory Chemist	Interferences - Accuracy/Bias - Precision	Within 75-125 RPD: ± 20%
Duplicate	Project designated sample matrix QC.	RPD: ± 20%	If result is indicative of matrix interference, discuss in case narrative. Otherwise check for possible source of error, and reanalyze the sample.	Analytical Laboratory Chemist	Interferences - Accuracy/Bias – Precision	RPD: ± 20%

Matrix: **Groundwater**

Analytical Group: **Alkalinity**

Analytical Method / SOP Reference: **EPA 310.1**
EMAX-310.1

QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per preparation batch	All analytes <1/2 QLs, except for common lab contaminants, wherein the standard is < QL	Re-prep and reanalyze LCS and all samples processed with the non-conforming LCS.	Analytical Laboratory Chemist	Accuracy/Bias - Contamination	All analytes <1/2 QLs
LCS	One per sample preparation batch	Witihin 80-120%	Re-prep and reanalyze LCS and all samples processed with the non-conforming LCS.	Analytical Laboratory Chemist	Accuracy/Bias	Witihin 80-120%
Duplicate	Project designated sample matrix QC.	RPD: ± 20%	If result is indicative of matrix interference, discuss in case narrative. Otherwise check for possible source of error, and reanalyze the sample.	Analytical Laboratory Chemist	Interferences - Accuracy/Bias – Precision	RPD: ± 20%

Matrix: Groundwater **Groundwater**

Analytical Group: **Metals**

Analytical Method /SOP Reference: **EPA 6020**
EMAX-6020

QC Sample	Frequency / Number	Method / SOP[a] QC Acceptance Limits[b]	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per preparation batch	No analytes detected > ½RL. For common laboratory contaminants, no analytes detected > RL. Blank result must not otherwise affect sample results.	Re-prep and reanalyze blank and all samples processed with the non-conforming blank.	EMAX Analyst	Accuracy/Bias - Contamination	No analytes > ½ RL (>RL for common lab contaminants) and greater than 1/10 the amount measured in any sample. Blank result must not otherwise affect sample results.
MS/MSD	Project designated sample matrix QC.	%Rec.: 75-125 RPD ± 20%	If result is indicative of matrix interference, discuss in case narrative. Otherwise check for possible source of error, and extract / reanalyze the sample.	EMAX Analyst	Interferences - Accuracy/Bias - Precision	%Rec.: 75-125 RPD +-20%
LCS	One per preparation batch	% Recovery: 80-120	Re-prep and reanalyze LCS and all samples processed with the non-conforming LCS.	EMAX Analyst	Accuracy/Bias	% Rec. : 80-120
ICP Serial Dilution (for ICP)	Per sample preparation batch.	1:5 dilution must agree within ± 10% of the original determination	Perform post digestion spike addition	EMAX Analyst	Accuracy/Bias)	1:5 dilution must agree within ± 10% of the original determination
Post Digestion Spike (for ICP)	When Dilution Test fails or analyte concentration in all samples < 50x LOD	Recovery within 75-125% of expected value	Run all samples by method of standard addition (MSA)	EMAX Analyst	Interferences - Accuracy/Bias - Precision	Recovery within 75-125% of expected value

Matrix: Groundwater **Groundwater**

Analytical Group: **Mercury**

Analytical Method /SOP Reference: **EPA 7470A**
EMAX-7470

QC Sample	Frequency / Number	Method / SOP[(a)] QC Acceptance Limits[(b)]	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per preparation batch	No analytes detected > ½RL. For common laboratory contaminants, no analytes detected > RL. Blank result must not otherwise affect sample results.	Re-prep and reanalyze blank and all samples processed with the non-conforming blank.	EMAX Analyst	Accuracy/Bias - Contamination	No analytes detected > ½RL. For common laboratory contaminants, no analytes detected > RL. Blank result must not otherwise affect sample results.
LCS	One per preparation batch	% Recovery: 80-120	Re-prep and reanalyze LCS and all samples processed with the non-conforming LCS.	EMAX Analyst	Accuracy/Bias	% Recovery: 80-120
MS/MSD	Project designated sample matrix QC.	% Recovery: 75-125 RPD ± 20%	If result is indicative of matrix interference, discuss in case narrative. Otherwise check for possible source of error, and extract / reanalyze the sample.	EMAX Analyst	Interferences - Accuracy/Bias - Precision	% Recovery: 75-125 RPD ± 20%

SAP Worksheet #29: Project Documents and Records Table

Document	Where Maintained
Field notes/logbook	Project file
Field forms	Project file
Sample labels	Analytical Laboratory
Chain-of-custody forms	Project file and Analytical laboratory
Supplies certification	Project file
Shipping records	Project file
Field audit and nonconformance reports	Project file
Laboratory data package including: Laboratory raw analytical data Sample receipt and login Laboratory internal COC Instrument calibration logs Sample preparation logs Sample analysis/run logs Second Column Configurations Manual Integrations Post Digest Spikes Nonconformance reports including corrective actions	Analytical Laboratory and project file; NAVFAC SW Administrative Record
Data validation report	Validator and project file NAVFAC SW Administrative Record

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SAP Worksheet #30: Analytical Services Table

Matrix	Analytical Group	Sample Locations/ ID Number	Analytical Method	Data Package Turnaround Time	Laboratory / Organization (name and address, contact person and telephone number)	Backup Laboratory / Organization (name and address, contact person and telephone number)
Groundwater	Perchlorate	Baseline Groundwater Sampling at IRP Site 1 (WS# 18)	EPA 314	21 Days	EMAX	
	Alkalinity		EPA 310.1			
	Anions & Bromide		EPA 300			
	Metabolic Gases		RSK 175			
	TOC		EPA 415			
Groundwater	Perchlorate	ISB Performance Monitoring Plan for Source Area PRB at IRP Site 1 (WS# 18)	EPA 314	21 Days		
	Alkalinity		EPA 310.1			
	Anions & Bromide		EPA 300			
	Metabolic Gases		RSK 175			
	TOC		EPA 415			
	Dissolved Metals		EPA 6020/7470A			
Groundwater	Perchlorate	ISB Performance Monitoring Plan for Source Area Treatment at IRP Site 1 (WS# 18)	EPA 314	21 Days		
	Alkalinity		EPA 310.1			
	Anions & Bromide		EPA 300			
	Metabolic Gases		RSK 175			
	TOC		EPA 415			

Matrix	Analytical Group	Sample Locations/ ID Number	Analytical Method	Data Package Turnaround Time	Laboratory/ Organization (name and address, contact person and telephone number)	Backup Laboratory/ Organization (name and address, contact person and telephone number)
Groundwater	Perchlorate	ISB Performance Monitoring Plan for Intermediate Area PRB at IRP Site 1 (WS# 18)	EPA 314	21 Days	EMAX	
	Alkalinity		EPA 310.1			
	Anions & Bromide		EPA 300			
	Metabolic Gases		RSK 175			
	TOC		EPA 415			
	Dissolved Metals		EPA 6020/7470A			
Groundwater	Perchlorate	ISB Performance Monitoring Plan for Station Boundary PRB at IRP Site 1 (WS# 18)	EPA 314	21 Days		
	Alkalinity		EPA 310.1			
	Anions & Bromide		EPA 300			
	Metabolic Gases		RSK 175			
	TOC		EPA 415			
	VOCs		EPA 8260B			
	Dissolved Metals		EPA 6020/7470A			
Groundwater	Perchlorate	Groundwater Monitoring Plan for Overall Perchlorate Extent Monitoring at IRP Site 1 (WS# 18)	EPA 314	21 Days		
Groundwater	VOCs	Sampling and Analysis Schedule for IRP Site 2 MNA (WS#18)	EPA 8260B	21 Days		

SAP Worksheet #31: Planned Project Assessments

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment	Person(s) Responsible for Responding to Assessment Findings	Person(s) Responsible for Identifying and Implementing Corrective Actions (CA)	Person(s) Responsible for Monitoring Effectiveness of CA
Field Readiness Review	Prior to mobilization of the project and prior to initiating major phases of work	Internal	AEJV	Gaurav Dhody Project Quality Manager AEJV	Crispin Wanyoike Project Manager AEJV	Crispin Wanyoike Project Manager AEJV	Gaurav Dhody Project Quality Manager AEJV
Field Sampling Surveillance	Once at the beginning of each of the field sampling activities event	Internal	AEJV	Leta Maclean Project Chemist AEJV	Crispin Wanyoike Project Manager AEJV	Crispin Wanyoike Project Manager AEJV	Gaurav Dhody Project Quality Manager AEJV & Leta Maclean Project Chemist AEJV
Data Review Surveillance	Once every deliverable	Internal	AEJV	Leta Maclean Project Chemist AEJV	Leta Maclean Project Chemist AEJV	Leta Maclean Project Chemist AEJV	Gaurav Dhody Project Quality Manager AEJV
Off-site Laboratory Technical Systems Audit	During DoD ELAP assessment or renewal of DoD ELAP certification	External	DoD ELAP	DoD ELAP Laboratory Evaluator	EMAX Analytical Lab QA Manager	EMAX Analytical Lab QA Manager	DoD ELAP QA POC

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment	Person(s) Responsible for Responding to Assessment Findings	Person(s) Responsible for Identifying and Implementing Corrective Actions (CA)	Person(s) Responsible for Monitoring Effectiveness of CA
Off-site Laboratory Technical Systems Audit	Every 2 years	External	CA DHS	CA DHS Laboratory Evaluator	EMAX Analytical Lab QA Manager	EMAX Analytical Lab QA Manager	CA DHS Laboratory Evaluator

Notes:
CA DHS – California Department of Health Services
DoD ELAP – Environmental Laboratory Accreditation Program

SAP Worksheet #32: Assessment Findings and Corrective Action Responses Table

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings	Timeframe of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response	Timeframe for Response
Field Sampling Surveillance	Surveillance Report	Crispin Wanyoike Project Manager AEJV	7 days after completion of the inspection	Corrective Action Report	Crispin Wanyoike Project Manager AEJV Gaurav Dhody Project Quality Manager AEJV If significant corrective actions occur as determined by the Project Manager and Project Quality Manager, a corrective action report will be submitted to the Navy within 1 week and regulatory agencies within 2 weeks via e-mail.	5 days after notification
Data Review Surveillance	Surveillance Report	Crispin Wanyoike Project Manager AEJV	7 days after completion of the inspection	Corrective Action Report	Crispin Wanyoike Project Manager AEJV Gaurav Dhody Project Quality Manager AEJV	14 days after notification
Management Review	Surveillance Report	Crispin Wanyoike Project Manager AEJV	7 days after completion of the inspection	Corrective Action Report	Gaurav Dhody Project Quality Manager AEJV	14 days after notification
Off-site Laboratory Technical Systems Audit - DoD ELAP	Per DoD ELAP	DoD ELAP Laboratory Evaluator	21 days after audit	Letter	EMAX Analytical Laboratory QA Manager	30 days

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings	Timeframe of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response	Timeframe for Response
Off-site Laboratory Technical Systems Audit – CA DHS	Per CA DHS	CA DHS Laboratory Evaluator	21 days after audit	Letter	EMAX Analytical Laboratory QA Manager	30 days

Notes:

CA DHS – California Department of Health Services

DoD ELAP – Environmental Laboratory Accreditation Program

SAP Worksheet #33: Quality Assurance Management Reports Table

Type of Report	Frequency (daily, weekly monthly, quarterly, annually, etc.)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation	Report Recipient(s)
Field Sampling Surveillance Report	Once at start up of sampling	To be determined when field schedule is finalized	Gaurav Dhody Project QC Officer AEJV	Morgan Rogers, RPM, BRAC Crispin Wanyoike, Project Manager, AEJV Philip Granger, Field Team Leader, AEJV
Off-site Laboratory Technical Systems Audit Report	During CA DHS certification or renewal of CA DHS certification	To be determined by CA DPH if off-site lab audit/re-certification is required	CA DHS Laboratory Evaluator	CA DHS representative EMAX Lab QA Manager
Data Review Surveillance Report	One after all data generated and reviewed	To be determined when field schedule is finalized	Leta Maclean Project Chemist AEJV	Crispin Wanyoike, Project Manager, AEJV Philip Granger, Field Team Leader, AEJV
Final Project Report	One after all field activities are completed	To be determined when field schedule is finalized	Crispin Wanyoike Project Manager AEJV	Morgan Rogers, RPM, BRAC Scott Kehe, BRAC

Note:

AEJV AECOM-Envirocon Joint Venture
BRAC Base Realignment and Closure
CA DHS California Department of Health Services
QA quality assurance
RPM remedial project manager

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SAP Worksheets #34-36: Data Verification and Validation (Steps I and IIa/IIb) Process Table

Data Review Input	Description	Responsible for Verification	Steps I/IIa/IIb[1]	Internal / External
Field logbook	Field logbooks will be reviewed weekly and verified that the information is complete. The inspection will be documented in daily QC reports.	Field Team Lead, AEJV	I	Internal
Chain-of-custody forms	Chain-of-custody forms will be reviewed daily to ensure that project information, sample analyses requested, number of field QC samples collected, and percent level III or IV validation chosen is accurate and in accordance with the requirements in this SAP.	Project Chemist, AEJV	I	Internal
Sample receipt	For samples shipped via courier or commercial carrier, the Project Chemist will verify receipt of samples by the laboratory the day following shipment. The sample cooler will be checked for compliance with temperature and packaging requirements.	Field Team Lead, AEJV Laboratory sample custodian EMAX	I	Internal External
Sample logins	Sample login information will be reviewed and verified for completeness in accordance with the COC forms.	Project Chemist, AEJV Laboratory Project Manager, EMAX	I	Internal External
Laboratory data prior to release	Laboratory data will be reviewed and verified for completeness against analyses requested on the COC forms.	Laboratory Project Manager, EMAX	I	External
	100 percent of the data comply with the method- and project-specific requirements; any deviations or failure to meet criteria are documented for the project file.	Laboratory Analyst EMAX		External
	100 percent of manual entries are free of transcription errors and manual calculations are accurate; computer calculations are spot-checked to verify program validity; data reported are compliant with method- and project-specific QC requirements; raw data and supporting materials are complete; spectral assignments are confirmed; descriptions of deviations from method or project requirements are documented; significant figures and rounding have been appropriately used; reported values include dilution factors; and results are reasonable.	Laboratory Peer Analyst EMAX		External
	Data reported are compliant with method- and project-specific QC requirements; the reported information is complete; the information in the report narrative is complete and accurate; and results are	Laboratory Supervisor EMAX		External

Data Review Input	Description	Responsible for Verification	Steps I/IIa/IIb[1]	Internal / External
	reasonable.			
	Data reported are compliant with method- and project-specific QC; analytical methods are performed in compliance with approved SOPs. This review may be conducted after release of data since they are done only on 10 percent of the data.	Laboratory Quality Assurance Manager EMAX		External
Laboratory data due at turnaround time listed on COC	Laboratory data will be verified that the analyses reported are consistent with the analyses requested on the COC forms.	Project Chemist, AEJV	I	Internal
Laboratory data packages	All laboratory data packages will be verified by the laboratory performing the work for completeness. Data packages will then be reviewed by the Project Chemist for completeness. Subsequently, data packages will be evaluated externally by undergoing third-party data validation.	EMAX Project Chemist, AEJV Third-party data validators, Laboratory Data Consultants	I	External Internal External
Field and electronic data	One hundred percent of manual entries will be reviewed against the hardcopy information and 10 percent of electronic uploads will be checked against the hardcopy.	Project Chemist, AEJV	I	Internal
Laboratory data packages	All laboratory data packages will be validated by the laboratory performing the work for technical accuracy prior to submittal.	Laboratory Project Manager EMAX	IIa	External
	Data packages will then be reviewed for accuracy against the laboratory data that was faxed/e-mailed at the turnaround time listed on the COC.	Project Chemist AEJV	IIa	Internal
	Data packages will be evaluated externally by undergoing third-party data validation.	Third-party data validator Laboratory Data Consultants	IIa	External
Data validation reports	Data validation reports will be reviewed in conjunction with the project DQOs and data quality indicators.	Project Chemist AEJV	IIb	Internal
DoD QSM (V4.1), CLP NFG and EPA SW 846	TOC, Alkalinity, Anions, Metabolic Gases, Tracers, Perchlorate, and VOCs	Third-party data validator Laboratory Data Consultants	IIa	External

Data Review Input	Description	Responsible for Verification	Steps I/IIa/IIb[1]	Internal / External
DoD QSM (V4.1), CLP NFG and EPA SW 846	TOC, Alkalinity, Anions, Metabolic Gases, Tracers, Perchlorate, and VOCs	Third-party data validator Laboratory Data Consultants	IIb	External

[1] IIa=compliance with methods, procedures, and contracts [see Table 10, page 117, UFP-QAPP manual, V.1, March 2005.]
IIb=comparison with measurement performance criteria in the SAP [see Table 11, page 118, UFP-QAPP manual, V.1, March 2005]

CLP NFG – EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review, June 2008.
CLP NFG – EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review, January 2010.
EPA SW 846 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846. 3rd ed., Revision 6. Office of Solid Waste. November 2007.

AEJV AECOM-Envirocon Joint Venture
CLP contract laboratory program
DoD Department of Defense
EPA Environmental Protection Agency, United States
NFG National Functional Guidelines
QC quality control
SAP sampling and analysis plan
TOC total organic carbon
VOC volatile organic compound

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SAP Worksheet #37: Data Usability Assessment

37.1 DATA VALIDATION

The following documents will be used as guidance for validating all data, except waste characterization samples:

- *Department of Defense Quality Systems Manual for Environmental Laboratories*, EDQW, Version 4.1 (4/22/2009)
- Contract Laboratory Program *National Functional Guidelines for Superfund Organic Methods Data Review, EPA-540-R-08-01* (EPA 2008),
- Contract Laboratory Program *National Functional Guidelines for Inorganic Superfund Data Review, EPA-540-R-10-011* (EPA 2010),
- *EWI #1, 3EN2.1, Chemical Data Validation* (SWDIV, 2001), and the
- QC criteria specified in this SAP.

Data validation will be performed by an independent data validation company. For this project, 90 percent of the data will require EPA Level III-equivalent data validation and 10 percent EPA Level IV-equivalent data validation. Data may be qualified as protocol or advisory. Protocol violations are when the laboratory deviates from the referenced analytical methods or the project-specific quantitation limits (QLs), QC limits, or QC criteria.

Field QC samples will be discussed in the validation reports as follows:

- **Field Blanks** – Identifications for trip blanks, will be provided on the COC forms by AEJV. Any analyte detected in field blanks will be discussed in this section of the report.

Data validation reports will be submitted to AEJV. The validation reports will be filed with the respective analytical data package.

37.2 DATA QUALITY ASSESSMENT

After data are validated, the Project Chemist will review and assess field and laboratory quality control. Data validation reports will be reviewed and assessed for meeting DQOs. The Project Chemist will review the data validation reports for any deviations and qualify data. The following data qualifiers will be used:

- J = Result is estimated
- U = Analyte is not detected at or above the stated QL
- R = Data are rejected
- UJ = Analyte is not detected, but there is an uncertainty about the QL

Data qualifiers are used to indicate uncertainties associated with the data. The assigned qualifiers will be entered into the validation code field in the database. The Project Chemist will prepare a data quality assessment report that will summarize the findings of the data assessment and discuss usability of the data to be included in the report.

Data will be reported in tabular format to be included in the report. The electronic data in the Navy Electronic Data Deliverable format will be submitted to the DON as described in *EWI EVR.6, Environmental Data Management and Required Electronic Delivery Standards* (NAFAC SW 2005). An e-mail confirmation received by AEJV will be forwarded to the project file.

37.3 MEASUREMENT QUALITY OBJECTIVE FOR CHEMICAL DATA

The primary measurement quality objective for the monitoring program relates to the precision and accuracy, including detections and quantitation limits, for the analytical methods performed. All analytical results will be evaluated in accordance with precision, accuracy, representativeness, completeness, comparability, and sensitivity (PARCCS) parameters to document the quality of the data and to ensure that the data are of sufficient quality to meet the project objectives. The following subsections describe each of the PARCCS parameters and how they will be assessed within this project.

37.3.1 Precision

Precision is the degree of mutual agreement between individual measurements of the same property under similar conditions. Laboratory precision is evaluated by collecting and analyzing duplicate subsamples and then calculating the variance between the samples, typically as a relative percent difference (RPD).

$$RPD = \frac{|A - B|}{\frac{(A + B)}{2}} \times 100\%$$

where:

A = First duplicate concentration

B = Second duplicate concentration

Laboratory analytical precision is evaluated by analyzing laboratory duplicates or MS and MSDs. MS/MSD samples will be generated for all chemical analytes for this project. The results of the analysis of each MS/MSD pair will be used to calculate an RPD for evaluating precision.

37.3.2 Accuracy

Field accuracy will be assessed by collecting and analyzing equipment rinsate, trip blank, and source water blank QC samples as appropriate. These QC samples will be used to evaluate the potential for target analytes to enter samples as a result of sampling processes.

A program of sample spiking will be conducted to evaluate laboratory accuracy. This program includes analysis of the MS and MSD samples, laboratory control samples (LCS) or blank spikes, surrogate standards, and method blanks. MS and MSD samples will be prepared and analyzed at a frequency of 5 percent for groundwater samples. LCS or blank spikes are also analyzed at a frequency of 5 percent. Surrogate standards, where applicable, are added to every sample analyzed for organic constituents. The results of the spiked samples are used to calculate the percent recovery for evaluating accuracy.

$$\text{Percent Recovery} = \frac{S - C}{T} \times 100$$

where:

S	=	Measured spike sample concentration
C	=	Sample concentration
T	=	True or actual concentration of the spike

Results that fall outside the accuracy goals will be further evaluated based on the results of other QC samples. Accuracy will be determined based on LCS recovery, in accordance with laboratory standard operating procedures.

37.3.3 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent the characteristics of a population, variations in a parameter at a sampling point, or an environmental condition that they are intended to represent. Representative data will be obtained for this project through careful selection of sampling locations and analytical parameters. Representative data will also be obtained through proper collection and handling of samples to avoid interference and minimize contamination.

Representativeness of data will also be ensured through the consistent application of established field and laboratory procedures. Field blanks (if appropriate) and laboratory blank samples will be evaluated for the presence of contaminants to aid in evaluating the representativeness of sample results. Data determined to be nonrepresentative, by comparison with existing data, will be used only if accompanied by appropriate qualifiers and limits of uncertainty.

37.3.4 Completeness

Completeness is a measure of the percentage of project-specific data that are valid. Valid data are obtained when samples are collected and analyzed in accordance with QC procedures outlined in this SAP, and when none of the QC criteria that affect data usability is exceeded. When all data validation is completed, the percent completeness value will be calculated by dividing the number of useable sample results by the total number of sample results planned for this investigation.

% completeness = 100 × (number of valid analyte results/number of possible results)

Completeness will also be evaluated as part of the data quality assessment process. This evaluation will help determine whether any limitations are associated with the decisions to be made based on the data collected.

37.3.5 Comparability

Comparability expresses the confidence with which one data set can be compared with another. Comparability of data will be achieved by consistently following standard field and laboratory procedures and by using standard measurement units in reporting analytical data.

37.3.6 Sensitivity

Sensitivity assesses the ability of the laboratory to detect target analytes using the methods and instruments selected for this project. Worksheet #15 lists the project action limits, project quantitation limits and laboratory-specific limits. Based on laboratory studies, the EPA methods and laboratory instrumentation have been selected for use on this project in order to detect target analytes at the project action limits.

37.4 USABILITY ASSESSMENT

A usability assessment to determine how well the data collected support the project objectives and decisions to be made will be performed by the project team. Any deviations from proposed field activities will be reviewed, and their effect on data usability evaluated. The analytical results of the groundwater sampling will be compared to the data quality indicators presented on Worksheets #12 and #28 to determine whether the measurement performance criteria were met. Upon completion of the verification and validation processes noted on Worksheets #34-36, the data quality indicators will be evaluated for each analytical group. Based on the results of this examination, conclusions regarding the validity and usability of data for each analytical group will be drawn. A data quality assessment report will be prepared by a data validator. Overall measurement error (sampling plus analytical) will be assessed as noted below. The remedial action report will include discussions of conclusions drawn and any limitations on the use of project data as a result of this assessment.

37.4.1 Personnel Responsible for Performing the Usability Assessment

The following personnel will be responsible for performing the data usability assessment for this project:

- The third party data validation firm's Project Manager will be responsible for performing the analytical data usability assessment for the environmental laboratory data.
- The Project Chemist will also perform a usability assessment of the validated environmental data.
- Subcontractors will perform data evaluations on data generated by their firms. These subcontractors have expertise in evaluating the respective data sets and will include the results of their evaluations in their respective reports.
- The Project Chemist and Project Manager will use the results of all evaluations and usability assessments to determine whether the data generated during the investigation can be used to answer the principal study questions.
- Field data generated by onsite staff including parameter monitoring data and lithologic descriptions recorded during drilling will be evaluated by the designated project personnel. The evaluations of these data sets will include reviewing the daily calibration logs and instrument maintenance logs and any field notes describing instrument use and performance during the field activities.

37.4.2 Data Usability Assessment Documentation

Data usability assessments will be documented in the remedial action report to be prepared for the project. Subcontractors providing data will include the results of their findings in their respective reports. The validation report will summarize the third party evaluations and include copies of respective subcontractor's reports.

Appendix A
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Appendix B
Analytical Laboratory Standard Operating Procedures

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STANDARD OPERATING PROCEDURE

DISSOLVED GASES

SOP No.:	EMAX-RSK175	Revision No.	2	Effective Date:	01-Sep-10
Prepared By:	Lucita Arzadon			Date:	09-01-10
Approved By:	Kenette Pimentel QA Manager			Date:	09·01·10
Approved By:	Caspar Pang Laboratory Director			Date:	9-01-10

Control Number: RSK175-02-

1.0 SCOPE AND APPLICATION

1.1. This method is used to determine dissolved methane, ethane and ethene in aqueous samples. This SOP is an adaptation of Dissolved Oxygen and Methane in Water by GC Headspace Equilibrium Technique published by R.S. Kerr Research Laboratory, commonly known as RSK 175.

1.2. This method is also used for carbon dioxide determination using an unpreserved sample and a Thermal Conductivity Detector (TCD).

1.3. This method is also amenable to propane, propene and isobutene or any other gases of similar structure, upon meeting all quality control criteria.

2.0 SUMMARY OF METHOD

2.1. A known volume of inert gas is injected into the sample contained in a septum cap vial, which subsequently displaces the same volume of sample into an injected empty disposable syringe. The injected gas is allowed to equilibrate with the sample by wrist mixing. Subsequently, a known amount of gas is aspirated from the headspace by a tight syringe with a locking device is analyzed for the target gases by GC with FID detector.

2.2. **Interferences**

2.2.1. Glassware can be a potential source of contamination. They must be scrupulously cleaned prior to its use.

2.2.2. Carry-over from a highly concentrated sample can be a potential source of contamination. Instrument performance must be observed keenly for possible carry-over. If this is apparent, inject solvent blank until no trace of carry-over is observed.

2.2.3. Deposits may adhere in the injection port/glass liner over a period of time and can cause interference. The injection port and glass liner must be routinely cleaned.

3.0 DETECTION LIMITS

3.1. **Method Detection Limit (MDL)**

3.1.1. Prepare a minimum of eight samples. Add MDL spike standard (refer to Section 9 for concentration level) to seven samples and treat one as method blank.

3.1.2. Analyze the samples as described in Section 10 and calculate the results as described in Section 10.6.

3.1.3. Refer to EMAX-QA04 for MDL evaluation and verification..

3.2. **Reporting Limit**

3.2.1. Reporting limit is equal to the concentration of the lowest calibration point, unless otherwise specified by the project

4.0 DYNAMIC RANGE

4.1. The highest quantifiable range requiring no dilution is equal to the concentration of the highest calibration point (See Section 9.3.1). Dilute and reanalyze all samples having results above this range to properly quantitate.

4.2. The lowest quantifiable range of diluted samples is equal to the lowest calibration point (See Section 9.3.1). Lower the dilution factor and reanalyze all diluted samples below this range to properly quantitate.

5.0 SAMPLE HOLDING TIME AND PRESERVATION

5.1. **Preservation**

5.1.1. Water samples are received in 40 ml vials with teflon-lined septa. The size of bubble caused by degassing upon cooling the sample should not exceed 6 mm.

5.1.2. Except for sample for carbon dioxide analysis, samples are preserved with concentrated HCl to pH < 2. Samples for carbon dioxide analysis must be analyzed from a sample with no chemical preservative.

5.1.3. All samples are stored at ≤ 6°C without freezing.

5.2. **Holding Time**

5.2.1. The holding time is 14 days from the time of collection.

5.2.2. For unpreserved water samples, the holding time is 7 days from collection date.

6.0 ASSOCIATED SOPs

6.1.	EMAX-QC02	Analytical Standard Preparation
6.2.	EMAX-SM04	Analytical and QC Sample Labeling
6.3.	EMAX-QA08	Corrective Action
6.4.	EMAX-DM01	Data Flow and Review
6.5.	EMAX-QA04	Method Detection Limit (MDL)
6.6.	EMAX-SM03	Waste Disposal

7.0 SAFETY

7.1. Read all MSDS for chemicals listed in this SOP.

7.2. All reagents, standards, and samples shall be treated as potential hazards. Observe the standard laboratory safety procedures. Protective gear, i.e., lab coat, safety glasses, gloves, shall be worn at all times when performing this procedure.

7.3. All wastes generated during analytical process shall be placed in the waste containers. These wastes shall be endorsed to waste disposal section for proper disposal.

7.4. If for any reason, solvent and/or other reagents get in contact with your skin or any other part of your body, rinse the affected body part thoroughly with tap water. If irritations persist inform your supervisor immediately so that proper action can be taken.

8.0 INSTRUMENTS, CHEMICALS AND REAGENTS

8.1. **Instruments and Supplies**

Gas Chromatography	For CO_2 HP 5890 Series II w/ TCD or equivalent Varian 3400 with FID, or equivalent
Column	Carboxen 30 m x 0.53 mm ID, 5 µm thickness (Supelco or equivalent)
Gas	ultra-high purity helium; ultra-high purity hydrogen
Syringes	Standard Syringe – 25 µL, 100 µL, 250µL, 5 ml Luerlock gas tight syringe with shut-off valve, or equivalent Helium Syringe – 3 ml and 5 ml Luerlock gas tight syringe with shut-off valve, or equivalent Displacement Syringe – 5 ml Luerlock disposable syringe
Microsyringes	25, 100, and 250 µl with a 0.006 mm ID needle (Hamilton 702N or equivalent) for dilution purposes
Data System	EZ-Chrom, HP Chem Station, or equivalent
Thermometer	0-100°C

8.2. **Chemicals and Reagents**

8.2.1. Solvent: Organic-free water

9.0 STANDARDS

9.1. **Stock Standard**

9.1.1. Purchase Stock Standards as certified solutions as listed below (or equivalent).

Standard Name	Source	Concentration (mg/L, v/v)	Intended Use
Gas mixture of ethane, ethylene and methane, propane, acetylene and CO_2 in Helium	Scotty Gases	500, 10%	ICAL, DCC*
Gas mixture of ethane, ethylene and methane, propane, acetylene and CO_2 in Helium	Matheson	500, 10%	ICV, LCS, MS*

Note: * Stock standards are being interchange for its intended use during calibration.

9.2. Stock standards are purchased as certified.

9.3. **Initial Calibration Standard (ICAL)**

9.3.1. Prepare the ICAL points at concentration levels as suggested in the table below to a final volume of 4 ml Helium. Refer to Equation 10.6.1.1 to convert standard concentration from µl/L to µg/L. Refer to Section 10.3 for ICAL preparation.

Standard		1	2	3	4	5	6
Primary Stock Std 500 mg/L		0.08	0.4	1.0	1.6	3.0	4.0
Final Concentration (µl/L):	C_2H_2	10	50	125	200	375	500
	CH_4	10	50	125	200	375	500
	C_2H_4	10	50	125	200	375	500
	C_2H_6	10	50	125	200	375	500
	C_3H_8	10	50	125	200	375	500
Final Concentration (µg/L) V_h/V_w = 4/39 T = 21 °C	C_2H_2	1.1	5.5	14	22	41	55
	CH_4	0.68	3.4	8.5	14	26	34
	C_2H_4	1.2	6	15	24	45	60
	C_2H_6	1.3	6.4	16	26	48	64
	C_3H_8	1.9	9.4	23	37	70	94

9.3.2.

Standard		1	2	3	4	5	6
Primary Stock Std 500 mg/L		0.25	0.5	1.0	2.0	3.0	4.0
Final Concentration (µl/L):	CO_2	6250	12500	25000	50000	75000	100000
Final Concentration (µg/L) V_h/V_w = 4/39 T = 21 °C	CO_2	1200	2300	4700	9300	14000	19000

9.4. **Initial Calibration Verification Standard (ICV) & LCS/MS Spike Standard**

9.4.1. Prepare the ICV standard using 1.6 ml of the second source stock standard to 4 ml of Helium.

Standard	C_2H_2	CH_4	C_2H_4	C_2H_6	C_3H_8	CO_2
Final Concentration (µl/L):	200	200	200	200	200	50000
Final Concentration (µg/L):	22	14	24	26	37	9300

9.5. **Continuing Calibration Standard (DCC)**

9.5.1. Prepare the DCC standard using 1.6-ml of ICAL stock standard to 4-ml of Helium.

Standard	C_2H_2	CH_4	C_2H_4	C_2H_6	C_3H_8	CO_2
Final Concentration (µl/L):	200	200	200	200	200	50000
Final Concentration (µg/L):	22	14	24	26	37	9300

10.0 PROCEDURES

10.1. **Sample Preparation**

10.1.1. Let the samples sit on a water bath for at least an hour or until the water bath equilibrates with the room temperature (26°C ±2°C). Record the temperature of the water bath in the sample preparation log.

10.1.2. Place the sample vial upside down and secure with a three finger clamp. Insert the sample displacement syringe, set for dead volume, into the sample by penetrating the septum to expose about one centimeter of the syringe needle into the sample.

10.1.3. From a freshly helium filled tedlar bag, using the helium syringe, measure 4-ml of helium into a gas tight Luerlock syringe lock it then insert it into the vial septum.

10.1.4. Open the syringe lock and inject the helium into the sample. As the helium is injected, sample is displaced from the vial into the empty syringe, creating a head space equivalent to the volume of helium injected.

10.1.5. Check the pH of the discarded sample and record in the sample preparation log.

10.1.6. Shake the vial for five minutes by quick wrist motion to allow gas to equilibrate between the liquid and gas phases.

10.1.7. The gas contained in the vial headspace is ready for analysis. Perform the analysis immediately upon completion of a preparative batch.

10.1.8. After analysis, empty the vial into a class 1 graduated cylinder and record the volume to the nearest 1-ml.

10.2. **Instrument Parameters**

10.2.1. Gas Chromatography Condition (FID)

Gases Setting:	
H_2	30 psi
Helium	30 psi
Air	500 psi
GC Setting	
Signal	1.43-1.56 mV
Injection Temperature	200 °C
Detector Temperature	225 °C
Injection Volume	100 µL
Head Pressure	12 psi
Carrier & Make-up gases + Air	300 mls/min.

Temperature Program	Temperature (°C)	Rate/min (°C)	Time (min)
Column	80	0	0
	220	30	4

10.2.2. Gas Chromatography Condition CO_2 (TCD)

Gases Setting:

H_2	30 psi
Helium	30 psi
Air	500 psi
GC Setting	
Injection Temperature	230°C
Detector Temperature	230°C
Injection Volume	100 µL
Head Pressure	10 psi

Temperature Program	Temperature (°C)	Rate/min (°C)	Time (min)
Column	80	0	1
	225	24	1

10.3. **Calibration**

10.3.1. Initial Calibration

10.3.1.1. Carefully fill a 40 ml VOA vial with reagent water. Care should be taken to avoid any trapped bubbles.

10.3.1.2. Setup the vial as described in Section 10.1.1.

10.3.1.3. Using a Luerlock gas tight syringe measure the desired amount of standard (refer to Section 9.3.1) and lock it. Using the helium syringe, measure the corresponding amount of helium to make a total of 4-ml volume of gas (standard plus helium) and lock it.

10.3.1.4. Insert the standard syringe and the helium syringe into the vial septum. Simultaneously inject the standard and the helium (as necessary) into the vial to displace 4-ml of reagent water into the displacement syringe. Lock the syringe after injection was completed to prevent sample back flow.

10.3.1.5. Remove the syringes and shake the vial for five minutes by quick wrist motion to allow gas to equilibrate between the liquid and gas phases.

10.3.1.6. With the vial positioned upright, withdraw 100 µl gas from the head space and analyze by GC.

10.3.1.7. Calculate the mean calibration factor and the relative standard deviation (%RSD) according to Equations 10.6.1.2 and 10.6.1.3.

10.3.1.8. Refer to Appendix 1 for acceptance criteria.

10.3.2. Initial Calibration Verification

10.3.2.1. Prepare and analyze an ICV standard (refer to Section 9.4.1) applying the same standard preparation technique as described in 10.3.1.

10.3.2.2. Refer to Appendix 1 for acceptance criteria.

10.3.3. Daily Continuing Calibration (DCC)

10.3.3.1. Check the validity of the ICAL by analyzing continuing calibration to bracket every preparative batch.

10.3.3.2. Calculate the percent difference using Equation 10.6.2.

10.3.3.3. Refer to appendix 1 for acceptance criteria. If non compliant consider the suggestions listed in 10.3.2.3 to correct the problem.

10.4. **Analysis**

10.4.1. Prepare analytical sequence as suggested below.

10.4.1.1. Instrument blank – inject 100-µL of helium to confirm absence of contamination from the system and the helium to be used for analysis.

10.4.1.2. DCC – to check the validity of the ICAL prior to sample analysis.

10.4.1.3. Method Blank – to confirm absence of contamination from the reagent water used for the standards preparation as well as the naturally occurring gases from the atmosphere.

10.4.1.4. Samples not to exceed 20 field samples.

10.4.1.5. MS/MSD – as required by the project.

10.4.1.6. LCS – Since DCC is prepared and analyze the same way as the LCS, the objective of analyzing LCS is the same as DCC.

10.4.2. Sample Result Evaluation

10.4.2.1. Check QC parameters as soon as the data is available.

10.4.2.2. When a chromatographic peak falls in the retention time window (Section 10.4.3.) of an analyte, it is considered as qualitatively identified. Calculate the concentration according to Section 10.6.3.

10.4.2.3. Check the concentration of identified target analytes. If the response exceeds the calibration range, re-analyze the sample to bring the response of the target analyte within the calibration range guided by the options below.

- If less than 10% of the original sample headspace was used in the sample analyses, a smaller injection from the same headspace can be made.
- Otherwise, a new sample is prepared at an appropriate dilution.

10.4.2.4. Rule out carry over. Check sample(s) analyzed after a highly concentrated sample that they do not have carry over.

10.4.3. Retention Time Windows

10.4.3.1. Obtain three non-consecutive measurements of retention time for each analyte within a 72-hour period and calculate the standard deviation according to Eq-10.6.3.

10.4.3.2. The magnitude of RTW is established by + 3 x SD.

10.4.3.3. RTW should be recalculated when GC condition changes or a new column is installed or at least once a year whichever comes first.

10.4.3.4. Set the retention time window in the data acquisition software guided by the retention time window study acquired. Allow a wider window based on historical settings to prevent false negatives.

10.4.4. Dealing with Carryover

10.4.4.1. Check the sample analyzed after a sample having target analyte concentrations exceeding the calibration range.

10.4.4.2. If there is no target analyte detected as found in the sample that exceeded the calibration range, proceed with data reduction.

10.4.4.3. If there is any target analyte detected as found in the sample that exceeded the calibration range, re-analyze the sample to rule-out carryover. If carryover is confirmed, proceed with data reduction and report the data from re-analysis.

10.5. **Data Reduction**

10.5.1. Make a copy of the analytical run log and highlight the data to be reported.

10.5.2. Collate the reportable raw data separating the QC results from the sample results.

10.5.3. Keep all other data generated with the analytical folder marked with "For record only".

10.5.4. Proceed to report generation applying the calculation formulas in 10.6 as appropriate.

10.6. **Calculations**

10.6.1. Initial Calibration

10.6.1.1. Standard Concentration from µl/L to µg/L

$$C = \frac{V_H}{V_W} \times C_V \left(\frac{273}{273 + T_C} \right) \times \frac{1}{22.4} M_{wt} \qquad \text{Eq. 10.6.1.1}$$

where:

C	–	Concentration of gas in water in µg/L
V_H	–	Head space volume (4ml)
V_W	–	Sample volume (39 ml)
C_V	–	concentration of gas in µL/L
T_C	–	room temperature (21°C ±2°C)
M_{wt}	–	Molecular Weight of gases:
		C_2H_2 – 26 (µg/µmol)
		CH_4 – 16 (µg/µmol)
		C_2H_4 – 28 (µg/µmol)
		C_2H_6 –30 (µg/µmol)
		C_3H_8 –44 (µg/µmol)
		CO_2 – 44 (µg/µmol)

10.6.1.2. Calculate for Calibration Factor (CF).

$$CF = \frac{R_a}{C_a} \qquad \text{Eq. 10.6.1.2}$$

where:

R_a	-	Response for analyte measured in peak area

C_a - Concentration of analyte to be measured (µg/L)

10.6.1.3. Calculate for Average Calibration Factor (ACF)

$$ACF = \frac{\sum CF_a}{n} \qquad \text{Eq. 10.6.1.3}$$

where:

ACF - average calibration factor

ΣCF_a - sum of calibration factors

n - number of calibration points

10.6.1.4. Calculate for Standard Deviation

$$SD = \sqrt{\frac{\sum_{i=1}^{N}(x_i - \bar{x})^2}{N-1}} \qquad \text{Eq. 10.6.1.4}$$

where:

SD - Standard deviation

xi - result at i^{th} measurement

x - mean

N - number of measurements

10.6.1.5. Calculate for % Relative Standard Deviation (%RSD).

$$\%RSD = \frac{SD}{ACF} * 100\% \qquad \text{Eq. 10.6.1.5}$$

where:

SD - standard deviation

ACF - average calibration factor

10.6.2. Calculate for Continuing Calibration Percent Difference (%D)

$$\%D = \frac{Ck - Cf}{Ck} * 100\% \qquad \text{Eq.10.6.2}$$

where:

% D - is the percent difference of DCC from known concentration.

Ck - known concentration of analyte, in µg/L

Cf - concentration found, in µg/L

10.6.3. Sample Results

$$C = \frac{R_a}{AFC} * D$$ Eq.-10.6.3

where:

C	-	Concentration of analyte to be measured (µg/L)
R_a	-	response for analyte measured in peak area
AFC	-	average response for an analyte
D	-	sample dilution factor

10.6.4. Accuracy and Precision

10.6.4.1. Percent Recovery (%R)

$$\%R = \frac{C_f - C}{C_s} * 100$$ Eq. 10.6.4.1

where:

C_f	-	concentration found
C	-	sample concentration
C_s	-	concentration of spike

10.6.4.2. Relative Percent Difference (RPD)

$$RPD = \left[\frac{R_1 - R_2}{R_{ave}} * 100\% \right]$$ Eq. 10.6.4.2

where:

R_1	-	% recovery of first measurement
R_2	-	% recovery of second measurement
R_{ave}	-	average % recoveries

10.6.5. Method Detection Limit

MDL = 3.14 * SD Eq.-10.6.5

where:

MDL	-	method detection limit
SD	-	standard deviation (see Eq-10.6.1.3) from 7 measurements.

10.7. **Report Generation**

10.7.1. Generate the method.txt file using WDBXC.exe.

10.7.2. Generate Lab Chronicle using Labchronx.exe

10.7.3. Generate the sample results using F1VXC.exe

10.7.4. Generate the QC summary using QCVXC.exe

10.7.5. Generate case narrative using CN1.exe

10.7.6. Arrange the analysis package in sequence as detailed below using section separators. Attach all raw data to every form generated, to include manual integration and re-analyses.

- Sample Results
- LCS Summary
- MS/MSD Summary
- ICAL Summary
- ICV Summary
- DCC Summary
- Analysis Log
- Extraction Log

10.8. **Data Review**

10.8.1. Perform a 100% data review in accordance to EMAX-DM01and the PSR.

- Check calibrations for accuracy, completeness and compliance to requirements.
- Check that concentration of target analytes reported are all within calibration range.
- Check that method blank is compliant to PSR.
- Check that LCS/LCD is/are within the project QC limits.
- Check that MS/MSD is properly evaluated.

10.8.2. Review the case narrative and check that it accurately describes what transpired in the analytical process.

10.8.3. Submit the analysis package for secondary review.

10.9. **Preventive Maintenance**

10.9.1. Instruments should receive routine preventive maintenance as suggested but not limited to the table below.

Maintenance Activity	Description	Frequency
GC Verification	Inspect and clean syringe. Check instrument parameters to ensure normal operating conditions. Change liner as necessary. Clean injection port as necessary. Check instrument performance (e.g., Daily calibration check, instrument blank)	Daily prior to analysis.
System Cleaning	Remove dust from fans and vent covers, inspect and clean inlet and detector. Check septa and replace as necessary.	Every 6 months or as necessary
Check Flow Path Components	Check and replace the following as necessary: tubing assembly, union, column	Once a year as necessary
Complete Inspection	Perform general inspection of the complete system. Inspect autosampler cabling and configuration setting.	Once a year
Documentation	Record all instrument maintenance performed in the instrument maintenance log.	Daily prior to analysis

11.0 QUALITY CONTROL

11.1. Method QC

11.1.1. Establish ICAL prior to analysis.

11.1.2. Establish DL, LOD and LOQ prior to using this method. Refer to EMAX-QA04 for evaluation and verification.

11.1.3. Update the Retention Time Window at least once a year or when a major instrument repair is done.

11.2. Analytical Batch

11.2.1. An instrument/solvent blank shall be performed prior to the first daily continuing calibration. The acceptance criteria shall be the same as the method blank.

11.2.2. Perform sample analysis with a valid ICAL. Analyze ICV to verify the concentration of the ICAL standards. Analyze DCC at a frequency and acceptance criteria as described in Appendix 1 to validate the ICAL.

11.3. Sample Preparation

11.3.1. All samples must be analyzed within the holding time.

11.3.2. The maximum number of original field samples in an analytical batch shall be 20 unless otherwise specified by the project.

11.3.3. Clean the purge needles thoroughly with high purity helium, after every use to ensure that there are no particulates adhering to it.

11.3.4. Prepare and analyze method blank, LCS (when required by the project), and MS/MSD (when designated by the project) for each every analytical batch applying the same analytical process as the field samples (Section 10.0).

11.3.5. Use organic free water for method blank and LCS.

11.3.6. Analyze LCS and MS/MSD samples as specified by the project. In the absence of any project designation, a sample duplicate with detected analytes or a LCS duplicate may be analyzed to establish precision.

11.3.7. Samples labeled preserved with HCl should have a pH of <2.

12.0 CORRECTIVE ACTION

12.1. Method QC

12.1.1. If ICAL is non-compliant consider the following to correct the problem:

- If one of the standards returns a bias-low or bias high on all of the analytes then that point is considered an outlier. Prepare a standard at that ICAL point and re-analyze.
- If the highest ICAL point appears to be saturated, drop the highest point.
- If the lowest point returns a bias low response or the peaks are not distinct and sharp, drop the point.

12.1.2. ***Note: The lowest calibration point identifies the reporting limit (RL). Therefore, check that the RL is in conformance to the current projects where the ICAL will be used.***

12.1.3. If ICV is non-compliant consider the following to correct the problem:

- If all analytes are bias low or bias high, it might be inaccurate amount of standard injected. Prepare another standard and re-analyze the ICV.
- If standard degradation is observed, prepare from a new standard lot and re-analyze the ICV.
- If the problem persist, perform instrument troubleshooting, check leaks, check gas flow rates, refer to GC trouble shooting manual and correct the problem. Re-calibrate the instrument and repeat ICV.

12.1.4. If LOD verification failed to meet the acceptance criteria, consider instrument maintenance prior to re-analyzing LOD verification, otherwise perform new detection limit study.

12.1.5. If retention time is significantly shifted, check the carrier gas flow or check for leaks. Perform RTW study and apply as necessary.

12.2. **Analytical Batch**

12.2.1. When instrument blank is non-compliant, fill a new tedlar bag with helium, clean the injection syringe and analyze the helium by direct injection. If the problem persist, either the injection port is contaminated or the helium source is contaminated. Consider the following suggestions to correct the problem.

- Check the helium source to make sure that the helium grade is ultra-high purity.
- Change the GC injector septa.
- Cut the column

12.2.2. If DCC is non-compliant, consider the following suggestion to correct the problem:

12.2.3. and suggested corrective action in Section 10.3.3 does not correct the problem, consult with the Supervisor for further advise prior to performing a new ICAL.

12.3. **Sample Preparation**

12.3.1. If method blank is non-compliant, investigate the source of the problem and institute resolution to correct, minimize or eliminate the problem. Consider the following suggestions to investigate the source of the problem.

- Check the reagent water source if it is due to change the filters.
- Check the vials source for possible change of manufacturer.
- Analyze the vial septa. Cut the septa in half and place it in a new vial, add 2 drops of HCl, and fill the vial with reagent water. Let it stand by for at least 1 hour then analyze it like a regular sample.

12.3.2. If the analyte found in the method blank is not detected in any of the field samples, consult with the Supervisor and the PM if the result can be reported otherwise, re-extract and re-analyzed the method blank prior to sample analysis.

12.3.3. When MS/MSD recovery failed to meet the QC limits, refer to Appendix 1 for corrective action and discuss it in the case narrative.

12.3.4. For insufficient amount of sample, note it in the sample preparation log, initiate an NCR, inform the PM immediately and discuss it in the case narrative.

12.3.5. When sample chemical preservation is insufficient (samples labeled preserved but the pH is >2), note it in the analytical run log comment section and discuss it in the case narrative.

12.4. **Non-Conformance Report (NCR)**

12.4.1. Initiate an NCR when the following circumstances occur:

- Anomalies other than specified in Appendix 1 is observed.
- Sample is out of technical holding time.

12.4.2. Refer to EMAX-QA08 for Non-Conformance Report details.

13.0 POLLUTION PREVENTION

13.1. Endorse all unused samples the Waste Disposal Unit (WDU) for proper disposal. No samples shall be dumped on the laboratory sink.

13.2. Endorse all unused expired analytical standards properly labeled/identified to WDU for proper disposal..

14.0 WASTE MANAGEMENT

14.1. Dispose all unused samples, expired analytical standards and other waste generated during the analytical process in accordance to EMAX-SM03.

15.0 SUPPLEMENTARY NOTES

15.1. **Definition of Terms**

15.1.1. Batch – is a group of samples that are prepared and/or analyzed at the same time using the same lot of reagents. Preparation batch is composed of one to 20 sample of the same matrix, a method blank, a lab control sample and matrix spike/matrix spike duplicate. Analytical batch is composed of prepared samples (extracts, digestates, or concentrates), which are analyzed together as a group using an instrument in conformance to the analytical requirement. An analytical batch can include samples originating from various matrices, preparation batches and can exceed 20 samples.

15.1.2. Calibration – is a determinant measured from a standard to obtain the correct value of an instrument output.

15.1.3. Instrument Method – is a file generated to contain the instrument calibration and instrument parameter settings for a particular analysis.

15.1.4. Instrument Blank – is target-free solvent subjected to the entire analytical process to establish zero baseline or background value.

15.1.5. Lab Control Sample (LCS) – is a target-analyte-free sample spiked with a verified known amount of target analyte(s) or a reference material with a certified known value subjected to the entire sample preparation and/or analytical process. LCS is analyzed to monitor the accuracy of the analytical system

15.1.6. Lab Control Duplicate Sample (LCD) – is a replicate of LCS analyzed to monitor precision when MS/MSD sample is not analyzed.

15.1.7. Matrix – is a component or form of a sample.

15.1.8. Matrix Spike (MS) – is a sample spiked with a verified known amount of target analyte(s) subjected to the entire sample preparation and/or analytical process. MS is analyzed to monitor matrix effect on a method's recovery efficiency.

15.1.9. Matrix Spike Duplicate – is a replicate of MS analyzed to monitor precision or recovery.

15.1.10. Method Blank – is a target-analyte-free sample subjected tot he entire sample preparation and/or analytical to monitor contamination.

15.1.11. Sample – is a specimen received in the laboratory bearing a sample label traceable to the accompanying COC. Samples collected in different containers having the same field sample ID are considered the same and therefore labeled with the same lab sample ID unless otherwise specified by the project.

15.1.12. Sample Duplicate – is a replicate of a sub-sample taken from one sample, prepared and analyzed within the same preparation batch.

15.1.13. Sub-sample – is an aliquot taken from a sample for analysis. Each sub-sample is uniquely identified by the sample preparation ID.

15.2. **Application of EMAX QC Procedures**

15.2.1. The procedures and QC criteria summarized in this SOP shall be applied to all samples unless otherwise other directive is specified by the project requirements.

15.3. **Department of Defense (DoD) Projects**

15.3.1. Samples from DoD sponsored projects shall follow the Quality Assurance Project Plan (QAPP), Statement of Work (SOW) and/or client's quality control directive. In the absence of QAPP, the DoD Quality Systems Manual (QSM), latest update, shall be applied.

15.4. **Department of Energy (DoE) Projects**

15.4.1. Samples from DoE sponsored projects shall follow the Quality Assurance Project Plan (QAPP), Statement of Work (SOW) and/or client's quality control directive. In the absence of QAPP, the DoE Quality Systems for Analytical Services (QSAS), latest update, shall be applied.

15.4.2. .

16.0 REFERENCES

16.1. DH Kampbell, JJ Wilson and S.A. Vandegrift. "Dissolved Oxygen and Methane in Water by a GC Head space Equilibration Technique". International Journal Environ Analytical Chem., Vol. 30, pp. 249-257, 1989

16.2. EMAX Quality Systems Manual, as updated.

17.0 APPENDICES

17.1. **Figures**

17.1.1. Figure 1 Peak Evaluation Technique

17.1.2. Figure 2 Typical Chromatogram

17.1.3. Figure 3 Typical ICAL Summary

17.1.4. Figure 4 Typical Continuing Calibration summary

17.1.5. Figure 5 Typical Sample Result Summary

17.1.6. Figure 6 Typical LCS Result Summary

17.1.7. Figure 7 Typical Case Narrative

17.2. **Appendices**

17.2.1. Appendix 1 Summary of Quality Control Procedures

17.2.2. Appendix 2 Demonstration of Capability

17.3. **Forms**

17.3.1. RSK175FS Sample Preparation Log

17.3.2. RSK175FA Analysis Run Log

17.3.3. RSK175FM Instrument Maintenance Log

Figure 1 - Peak Evaluation Technique

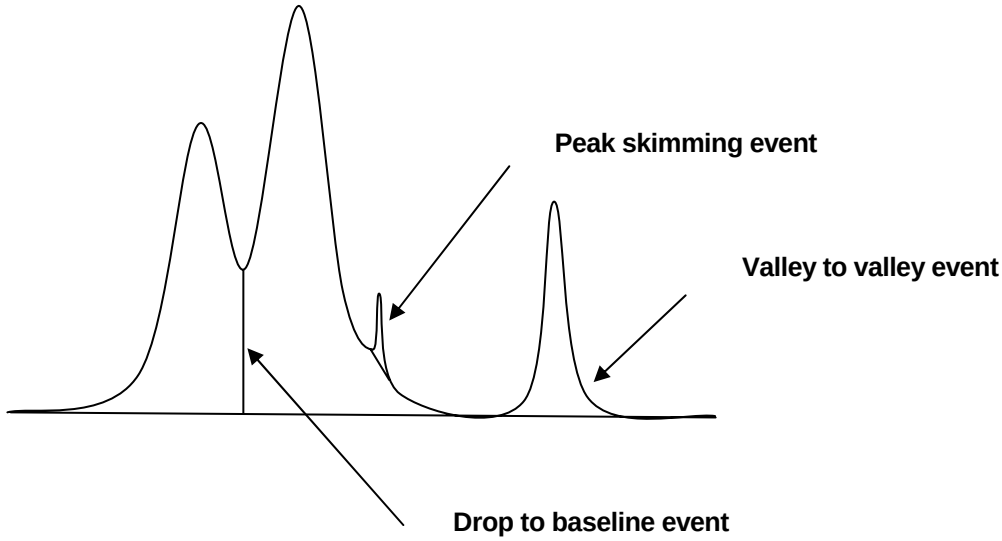


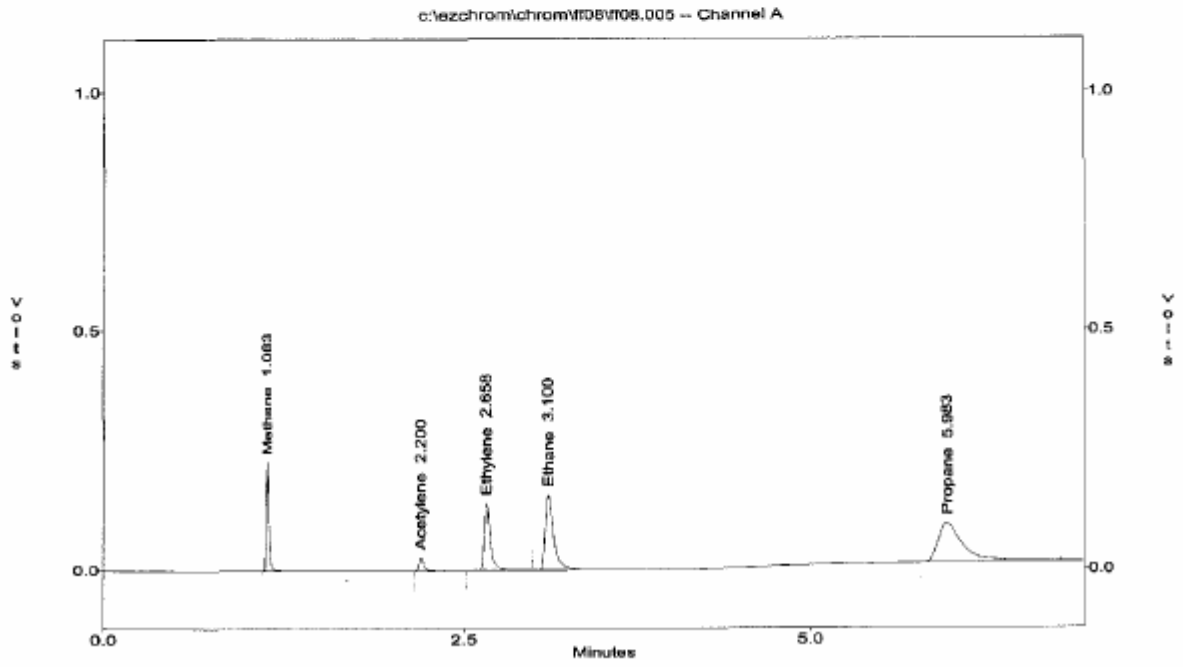
Figure 2: **Typical Chromatogram**

EPA DGAS by GC/FID
EMAX Analytical Laboratories, Inc.

File : c :\ezchrom\chrom\ff08\ff08.005
Method : c :\ezchrom\methods\dg10f08.met
Sample ID : DG10F08-04
Acquired : Jun 08, 2010 11:59:13
Printed : Jun 08, 2010 12:50:16
User : SERGIO

Channel A Results

#	Peak Name	Ret. Time(Min)	Area	Ave. CF	ESTD Conc.(ppb)
1	Methane	1.083	375408.0	29810.9	13.56
2	Acetylene	2.200	66426.0	3093.7	22.00
3	Ethylene	2.658	410094.0	18047.8	23.73
4	Ethane	3.100	645905.0	26515.2	25.42
5	Propane	5.983	1020912.0	28066.5	37.28



RS 6/9/10

Figure 3: **Typical ICAL Summary**

INITIAL CALIBRATION
DISSOLVED GASES

Lab Name : EMAX Inc
Instrument ID : GCT010
GC Columm : CARBOXEN 1006PLOT
Column size ID : 30MX0.53MM
LFID & Datetime: FF08002A 06/08/10 11:18
LFID & Datetime: FF08003A 06/08/10 11:33
LFID & Datetime: FF08004A 06/08/10 11:47
LFID & Datetime: FF08005A 06/08/10 11:59
LFID & Datetime: FF08006A 06/08/10 12:13
LFID & Datetime: FF08007A 06/08/10 12:26
CONC UNIT: ppb

COMPOUND	CONC X	CALIBRATION FACTORS (AREA)/UNIT 2.00X	10.00X	25.00X	40.00X	75.00X	100.00X	MEAN	%RSD
Methane	0.34	33825	28613	30200	27685	29094	29449	29810.9	7.2
Acetylene	0.55	2898	2988	3307	3019	3074	3275	3093.7	5.3
Ethylene	0.59	17193	17499	19207	17282	18239	18867	18047.8	4.7
Ethane	0.64	25049	25758	28048	25409	27126	27701	26515.2	4.8
Propane	0.93	26052	28288	29817	27385	27981	28877	28066.5	4.6

DG10F08.MET

Figure 4: **Typical Continuing Calibration Summary**

CONTINUING CALIBRATION
DISSOLVED GASES

Lab Name : EMAX Inc
Instrument ID : GCT010
GC Columm : CARBOXEN 1006PLOT
Column size ID : 30MX0.53MM
Mid Conc Init LFID & Datetime: FF08005A 06/08/2010 11:59
Conc Cont LFID & Datetime: FF30002A 06/30/2010 11:16
CONC UNIT : ppb

COMPOUND	RT MINUTES	RT WINDOW FROM	TO	TRUE CONC	AVERAGE CF	RESULT AREA	CONC	%D	QL	%D LIMITS
Methane	1.083	1.054	1.112	13.6	29810.9	406771	13.65	1		15
Acetylene	2.200	2.174	2.226	22.0	3093.7	68897	22.27	1		15
Ethylene	2.658	2.607	2.709	23.7	18047.8	437414	24.24	2		15
Ethane	3.092	3.042	3.142	25.4	26515.2	693643	26.16	3		15
Propane	5.975	5.888	6.062	37.3	28066.5	1071076	38.16	2		15

Figure 5: **Typical Sample Result Summary**

RSK-175
DISSOLVED GASES

Client	: XYZ, INC.	Date Collected:	06/23/10
Project	: CLEAN LAND PROJECT	Date Received:	06/24/10
Batch No.	: 10F299	Date Extracted:	06/29/10 09:30
Sample ID:	129178-7437	Date Analyzed:	06/29/10 11:59
Lab Samp ID:	F299-02	Dilution Factor:	1
Lab File ID:	FF29008A	Matrix :	WATER
Ext Btch ID:	DGF013W	% Moisture :	NA
Calib. Ref.:	FF29002A	Instrument ID :	GCT010

PARAMETERS	RESULTS (ug/L)	LOQ (ug/L)	LOD (ug/L)
ACETYLENE	ND	2.0	0.6
ETHANE	ND	2.0	0.6
ETHENE	ND	2.0	0.6
METHANE	1.2J	2.0	0.3
PROPANE	ND	2.0	0.9

RL: Reporting Limit

Figure 6: **Typical LCS Result Summary**

EMAX QUALITY CONTROL DATA
LCS/LCD ANALYSIS

CLIENT:	XYZ, INC.				
PROJECT:	CLEAN LAND PROJECT				
BATCH NO.:	10F299				
METHOD:	RSK-175				
MATRIX:	WATER			% MOISTURE:	NA
DILUTION FACTOR:	1	1	1		
SAMPLE ID:	MBLK1W				
LAB SAMP ID:	DGF013WB	DGF013WL	DGF013WC		
LAB FILE ID:	FF29003A	FF29004A	FF29005A		
DATE EXTRACTED:	06/29/1009:30	06/29/1009:30	06/29/1009:30	DATE COLLECTED:	NA
DATE ANALYZED:	06/29/1010:31	06/29/1010:49	06/29/1011:09	DATE RECEIVED:	06/29/10
PREP. BATCH:	DGF013W	DGF013W	DGF013W		
CALIB. REF:	FF29002A	FF29002A	FF29002A		

ACCESSION:

PARAMETER	BLNK RSLT (ug/L)	SPIKE AMT (ug/L)	BS RSLT (ug/L)	BS % REC	SPIKE AMT (ug/L)	BSD RSLT (ug/L)	BSD % REC	RPD (%)	QC LIMIT (%)	MAX RPD (%)
Acetylene	ND	25.2	27.7	110	25.2	28.3	112	2	60-140	30
Ethane	ND	25.4	25.4	100	25.4	25.6	101	1	65-115	20
Ethene	ND	23.7	23.6	99	23.7	23.6	100	0	65-115	20
Methane	ND	13.6	13.2	97	13.6	13.3	98	1	60-120	20
Propane	ND	13.6	13.9	102	13.6	14.1	103	1	50-140	30

Figure 8: **Typical Case Narrative**

CLIENT : XZY, INC.

PROJECT : CLEAN LAND PROJECT

SDG : 10F299

RSK-175
DISSOLVED GASES

A total of six (6) water samples were received on 06/24/10 for Dissolved Gas analysis, Method RSK-175 in accordance with R.S. Kerr Environmental Research Laboratory, Ada, OK 74820 March 15, 1989 and AFCEE QAPP, Version 4.0.

Holding Time
Samples were analyzed within the prescribed holding time.

Calibration
Calibration was performed as prescribed by the method and was verified using a secondary source (ICV). All calibration requirements were within acceptance criteria.

Method Blank
Method blank was analyzed at the frequency required by the project. For this SDG, one method blank was analyzed with the samples. Result was compliant to project requirement.

Lab Control Sample
A set of LCS/LCD was analyzed with the samples in this SDG.
Percent recoveries for DGF013WL/C were all within QC limits.

Matrix QC Sample
A set of MS/MSD was analyzed with the samples in this SDG.
Percent recoveries were within project QC limits except for results qualified with [*] in F299-02 M/S summary form, most likely due to matrix interference. Check QC summary form for details.

Sample Analysis
Samples were analyzed according to prescribed analytical procedures. All project requirements were met otherwise anomalies were discussed within the associated QC parameter.

Appendix 1: **SUMMARY OF QUALITY CONTROL PROCEDURES**

QC PROCEDURE	FREQUENCY	ACCEPTANCE CRITERIA	CORRECTIVE ACTION	1st Rvw	2nd Rvw
Five-point initial calibration for all analytes	Initially; as needed	% RSD for all analytes ≤ 20%	Correct the problem then repeat initial calibration		
Initial Calibration verification - ICV (Second-source)	After initial calibration	All analytes within ±25% of expected value	Correct the problem then repeat initial calibration		
Calibration verification	Bracket every 12 hours and at the end of the analytical run.	All analytes within ±15% of expected value	Correct the problem then repeat initial calibration verification and reanalyze all samples since last successful calibration verification		
Method blank	One per preparation batch (≤ 20 samples per matrix)	No analytes detected ≥ ½ LOQ	If sample results are ND or sample result >10X than the contamination level, consult with the PM if results are reportable. Otherwise, re-extract and reanalyze method blank and all samples processed with the contaminated blank. If re-extraction/re-analysis is not possible, apply B to specific analyte(s) on all associated.		
LCS	As required by the project. One LCS per preparation batch (≤ 20 samples per matrix)	In the absence of project QC Limits use EMAX QC limits	Re-extract and reanalyze the LCS and all associated samples		
MS/MSD	As required by the project.	In the absence of project QC Limits use EMAX QC limits	If chromatogram exhibits matrix interference narrate observation in the case narrative. Otherwise, check that spike value added is appropriately accounted. If anomaly is suspected, re-extract and re-analyze the matrix spike samples.		
Comments: Refer to PSR for Flagging Criteria.			Reviewed by:		
			Date:		

Appendix 2: **DEMONSTRATION OF CAPABILITY**

METHOD RSK175
(DISSOLVED GASES)

Conc. Unit: µg/L

Date Analyzed: 06/29/10

Sample Amount(ml): 39

Analyzed by: SC

PARAMETER	FF29004	FF29005	FF29006	FF29007	TV	Ave. Conc.	Ave. %Rec	SD	RSD	QC Criteria	Comments
Methane	13.2	13.3	13.7	13.6	13.6	13.4	99	0.24514	2	70 - 130	Passed
Acetylene	20.8	20.8	21.9	21.3	22.0	21.2	96	0.53024	3	70 - 130	Passed
Ethene	23.6	23.6	24.5	24.2	23.7	24.0	101	0.45669	2	70 - 140	Passed
Ethane	25.4	25.6	26.2	26.2	25.4	25.9	102	0.42289	2	70 - 140	Passed
Propane	34.2	39.7	38.7	38.4	37.3	37.7	101	2.43236	6	70 - 130	Passed

Conc Unit µg/L

Date Analyzed: 7/22/2010 - 07/28/10

Sample Amount(g): 39

Analyzed by: L. Arzadon

Volumet Extracted(ml): 4

PARAMETER	CSG004	CSG005	CSG025	CSG026	TV	Average Conc.	Average % Rec.	SD	RSD	QC Criteria	Comments
Carbon Dioxide	8900	8400	10500	10500	9300	9575	103	1087.428	11	60 - 140	Passed

RSK175FA: **ANALYTICAL RUN LOG**

EMAX LABORATORIES, INC.

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ANALYSIS RUN LOG
for
DISSOLVED GAS

Note: For samples and relevant QCs/Standards analyzed, refer to attached analytical sequence.

Comments:

Book #: A10-023

Instrument No.: 10

Analytical Sequence:

Method File:

Analytical Batch:

SOP #	Rev. #
☐ EMAX-RSK175	
☐ EMAX-RSK175M	
☐ EMAX-	

STANDARDS ID	Conc (µg/L)
Temperature (°C)	
Data File	

ELECTRONIC DATA ARCHIVAL	
Location	Date
Labbkup/Ezchrom/EZC_9_DGAS	

Analyzed By:

Date:

Disposed By:

Date Disposed:

RSK175FS: **SAMPLE PREPARATION LOG**

EMAX LABORATORIES, INC.

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EXTRACTION LOG FOR DISSOLVED GAS

SOP ☐ EMAX-RSK175 Revision No.: 2 ☐ CO2 ☐ Room Temp. (°C): Book # EDG-023

Start Date: Time: End Date: Time:

PREPARATION BATCH # _____

Sample Prep ID	Lab Sample ID	Sample Amount (g/ml)	Extract Volume (ml)	pH	Notes
01					
02					
03					
04					
05					
06					
07					
08					
09					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					

Standards	ID	Amount Added (µl)
LCS/MS		

Reagent	Lot# / ID
H_2O	
He	

SDG #	Extract Location

Comments: _____

Prepared By: _____

Standard Added By: _____

RSK175FM: **INSTRUMENT MAINTENANCE LOG**

EMAX LABORATORIES, INC.

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INSTRUMENT MAINTENANCE LOG

Instrument No: 10 Month Year: 201_ Book # M10-006

DATE							
Computer Date/Time							
Printer Paper							
GC Keyboard Check							
Check Temperature Program							
Column Head Pressure							
Carrier Source Pressure*							
Bake GC							
H2 Generator: 40-50 psi							
Instrument Blank							
Analyst's initial							
Notes: * To insure proper operation, make sure that carrier source pressure is at least 20 psi greater than the column head pressure.							
Trouble Shooting							
Problem(s) Encountered							
Return-to-Control (Analyst initial)							

Code	Problems Encountered	Code	Corrrective Action

STANDARD OPERATING PROCEDURES

ION CHROMATOGRAPHY ANALYSIS

SOP No.:	EMAX-300.0	Revision No.	7	Effective Date:	11-Oct-11
Prepared By:	Lucita Arzadon			Date:	10-05-11
Approved By:	Kenette Pimentel QA Manager			Date:	10.05.11
Approved By:	Caspar Pang Laboratory Director			Date:	10-05-11

Control Number: 300.0-07

1.0 SCOPE AND APPLICATION

1.1. This method is applicable for determination of inorganic anions in surface water, mixed domestic and industrial waste waters, ground waters and reagent waters, solids and leachates by Ion Chromatography. List of analytes determined and established in this SOP are: fluoride, chloride, bromide, bromate, nitrite-N, nitrate-N, ortho-phosphate-P, sulfate & iodide. Other inorganic anions may be analyzed provided that qualitative identification and quantitative determination is established through demonstration of capability.

1.2. This SOP is an adaptation of USEPA EPA Method 300.0.

2.0 SUMMARY OF METHOD

2.1. A small amount of sample (20 µl) is injected into an ion chromatograph. The sample is passed through a guard column, anion exchange column, suppressor device and the anions are detected by a conductivity detector.

2.2. **Interferences**

2.2.1. **Direct Chromatographic Coelution –** occurs when a non-target analyte elutes very close to the retention time of target analytes. This interference may be solved by changing the column, eluent strength, modifying the eluent with organic solvents (if compatible with IC columns), changing the detection systems or selective removal of the interference.

2.2.2. **Concentration Dependant Coelution** – occurs when the response of the neighboring peak overlaps into the retention time window of the target anion. Sample dilution or eluent dilution may resolve this interference.

2.2.3. **Ionic Character Displacement –** occurs when the retention times may significantly shift due to the influence of high ionic strength matrices (high mineral content or hardness) overloading the exchange sites in the column and significantly shortening the target analytes' retention times. Sample dilution or eluent dilution may resolve this interference.

2.2.4. **Method Interferences –** may be caused by reagents, glassware and other substance that the sample may get in contact during the analytical process. It is imperative that reagent water production is monitored. Only reagent grade or better reagents are use. Eluate must be passed through 0.2-µm filter. Columns must be sufficiently flushed.

2.2.5. **Anion Retention in the Column–** anion may temporarily adhere into the column and may elute in the retention time window of fluoride and potentially interfere. Fluoride concentration above 1.5 mg/L may not be significant but the analyst must be sure that the number reported is not a false positive.

2.2.6. **Carry Over Peaks –** may be caused by a preceding sample with high concentration or a late eluting compound. Ozonated and chlorine dioxide matrices were observed to have unknown

analytes that elutes at approximately 23 minutes. Extending the runtime to 24 minutes to allow elution of any interfering peaks may eliminate potential carry over of late eluting peaks.

3.0 DETECTION LIMITS

3.1. **Detection Limits (DL), Limit of Detection (LOD) & Limit of Quantitation (LOQ)**

3.1.1. Refer to EMAX-QA04 for generation, validation and verification of DL, LOD and LOQ.

3.1.2. Refer to Table 1 for established detection limits.

4.0 DYNAMIC RANGE

4.1. The highest quantifiable range requiring no dilution is equal to the concentration of the highest calibration point (see Section 9.3). All samples analyzed above this range shall be considered "over range" and shall require dilution to properly quantitate.

4.2. The lowest quantifiable range of diluted samples is equal to the concentration of the lowest calibration point. All diluted samples analyzed below this range shall be considered as "under range" and shall require lower dilution factor to properly quantitate.

5.0 SAMPLE HOLDING TIME & PRESERVATION

5.1. Aqueous samples received in the lab are expected to be contained in either HPDE or glass bottles, cooled at ≤ 6°C without freezing.

Analyte	Chemical Preservative	Holding Time	
		Unpreserved	Preserved
Fluoride	None	28 days	N/A
Chloride	None	28 days	N/A
Nitrite-N	None	48 hours	N/A
Bromide	None	28 days	N/A
Nitrate-N	None	48 hours	N/A
Ortho-Phosphate-P	None	48 hours	N/A
Sulfate	None	28 days	N/A
Iodide	None	28 days	N/A
Nitrate/Nitrite-N	pH ≤ 2 with H_2SO_4	28 Days	28 days
Bromate	None	28 Days	N/A

5.2. Soil samples received in the lab are expected to be contained in glass jars or brass tubes and cooled at ≤ 6°C without freezing. Samples shall be extracted within 28 days from sampling date. Holding time of extracts are the same as aqueous samples.

5.3. Store samples and extracts at ≤ 6°C without freezing until analysis is completed.

6.0 ASSOCIATED SOPs

6.1. EMAX-DM01 Data Flow and Review

6.2. EMAX-QA04 Method Detection Limit

6.3. EMAX-QA05 Training

6.4. EMAX-QA08 Corrective Action

6.5. EMAX-QC02 Analytical Standard Preparation

6.6. EMAX-QC07 Glassware Cleaning

6.7. EMAX-SM03 Waste Disposal

6.8. EMAX-SM04 Analytical and QC Sample Labeling

7.0 SAFETY

7.1. Read all MSDS for chemicals listed in this SOP.

7.2. All reagents, standards and samples shall be treated a potential hazards. Observe the standard laboratory safety procedures. Protective gear, i.e. lab coat safety glasses, gloves, shall be worn at all times when performing this procedure.

7.3. If for any reason, solvent and/or other reagents get in contact with your skin or any other part of your body, rinse the affected body part thoroughly with copious amounts of tap water. If irritations persist inform your supervisor immediately so proper action can be taken.

8.0 INSTRUMENTS, CHEMICALS AND REAGENTS

8.1. **Instrumentation**

	D0	D7	E3
IC	Metrohm 761 Compact IC	Metrohm IC 800 Series	Methrohm 881 Compact IC Pro
Guard Column	Metrosep RP Guard		
Column	Metrosep A Supp 5 (100/4.0 mm)	Metrosep A Supp 5 (150/4.0mm)	Metrosep A Supp 7 (250x4 mm) 5µm
Detector	Detector Block		
Autosampler	788 IC Filtration Sample Processor	838 Advanced Sample Processor	858 Professional Sample Processor
Data Acquisition	IC Net 2.3		Magic Net 1.1
Balance	Toploading, sensitive to ± 0.0001 gm		

8.2. **Chemicals**

Reagent water	Reagent water – anion-free and interferent-free water
$NaHCO_3$	Bicarbonate Eluent Stock Solution 100 mM $NaHCO_3$, Reagent grade available commercially or

	Dissolve 8.4 $NaHCO_3$ to 1-Liter of reagent water.
Na_2CO_3/ $NaHCO_3$	Carbonate and Bicarbonate Eluent Stock Solution Instrument 100 320/100 mM, Reagent grade available commercially or Dissolve 33.92 g of sodium carbonate (Na_2CO_3) and 8.40 g of sodium bicarbonate ($NaHCO_3$) using reagent water into 1-Liter solution. Instrument 107 350/100 mM, Reagent grade available commercially or Dissolve 37.10g of sodium carbonate (Na_2CO_3) and 8.40g of sodium bicarbonate ($NaHCO_3$) using reagent water into 1-Liter solution. Instrument E3 360 mM, Reagent grade available commercially or Dissolve 38.156 g of sodium carbonate (Na_2CO_3) using reagent water into 1-Liter solution.
Sulfuric Acid (IC Regenerant)	100 mM Reagent Grade
Working Eluent Solution	Instrument: 100 3.2 Na_2CO_3/1.6 $NaHCO_3$mM Add 20.0 ml of 320 mM Na_2CO_3 / 100 mM combined $NaHCO_3$ and 12 ml of 100 mM $NaHCO_3$ solution into a 2-Liter volumetric flask and dilute to the mark with reagent water. Intrument : 107 3.5 Na_2CO_3/2.0 $NaHCO_3$mM Add 20.0 ml of 350 mM Na_2CO_3 / 100 mM combined $NaHCO_3$ and 20ml of 100mM $NaHCO_3$ solution into a 2-Liter volumetric flask and dilute to the mark with reagent water. *(Note: Degas both solutions with high purity N_2 gas for a minimum of 2 hours prior use)* Instrument: E3 3.6 mM Na_2CO_3 Add 20.0 ml of 360 mM Na2CO3 into a 2-Liter volumetric flask and dilute to the mark with reagent water.

8.3. **Supplies**

Autosampler vials	11 ml PP sample tubes
Filters	0.022 µm Gelman IC acrodisc 4485 or equivalent
Volumetric Flasks	100, 200, 1000, 2000 ml

Autosampler vials	11 ml PP sample tubes
Containers	50 ml, 125 ml plastic snap seal
Micropipettes	1 and 5 ml; 200 µL

9.0 STANDARDS

9.1. Standard Preparation

9.1.1. Refer to EMAX-QC02 for proper preparation of analytical standards.

9.1.2. Store all standard solutions in ≤ 6°C without freezing.

9.1.3. Standard concentrations stipulated in this SOP are recommended concentration levels. In the event that concentrations are changed, perform all quality control procedures, apply related acceptance criteria and obtain Supervisor approval prior to use.

9.2. Stock Standards Solution (SSS)

9.2.1. **Primary Stock Standards** are purchased commercially as certified solutions. These standards are primarily used for calibration.

Stock Standard		Conc. (mg/L)
Fluoride(F)	ERA or equivalent	1,000
Chloride(Cl)	ERA or equivalent	1,000
Nitrite-N(NO_2-N)	ERA or equivalent	1,000
Bromide(Br)	ERA or equivalent	1,000
Nitrate-N(NO_3-N)	ERA or equivalent	1,000
Phosphate-P(o-PO_4-P)	ERA or equivalent	1,000
Sulfate(SO_4)	ERA or equivalent	1,000
Iodide(I)	AccuStandard or equivalent	1,000
Bromate(BrO_3)	ERA or equivalent	10,000

9.2.2. **Secondary Stock Standards** are purchased commercially as certified solutions from a different source. This standard is use to prepare for ICV, and QCS.

Stock Standard		Conc. (mg/L)
Fluoride(F)	AccuSpec or equivalent	1,000
Chloride(Cl)	AccuSpec or equivalent	1,000
Nitrite-N(NO_2-N)	AccuSpec or equivalent	1,000
Bromide(Br)	AccuSpec or equivalent	1,000
Nitrate-N(NO_3-N)	AccuSpec or equivalent	1,000
Phosphate-P(o-PO_4-P)	AccuSpec or equivalent	1,000
Sulfate(SO_4)	AccuSpec or equivalent	1,000
Iodide(I)	Inorganic Ventures or equivalent	1,000
Bromate(BrO_3)	Accuspec or equivalent	1,000

9.2.3. **Preparation of Intermediate Standard**

9.2.3.1. Intermediate standard, 100.0 mg/L. Dilute 10 ml of stock solution to 100 ml with reagent water.

9.2.3.2. Nitrate, Nitrite and Phosphate should be prepared fresh on the day they are used. All other analytes can be prepared weekly.

9.2.3.3. Store all standards in ≤ 6°C without freezing.

9.3. **Initial Calibration Standard (ICAL)**

9.3.1. Prepare a minimum of three Initial Calibration Standards and a calibration blank in a 100 ml volumetric flask, guided by the table below. Additional calibration points may be added and/or the concentrations may be varied as long as the acceptance criteria are met.

Analyte	S0		S1		S2		S3	
	Std (ml)	Conc (mg/L)	100 mg/L Std (ml)	Conc (mg/L)	100 mg/L Std (ml)	Conc (mg/L)	100 mg/L Std (ml)	Conc (mg/L)
Fluoride (F)	0	0	0.1	0.1	0.2	0.2	0.5	0.5
Chloride (Cl)	0	0	0.1	0.1	0.2	0.2	0.5	0.5
Nitrite (NO_2-N)	0	0	0.1	0.1	0.2	0.2	0.5	0.5
Bromide (Br)	0	0	0.1	0.1	0.2	0.2	0.5	0.5
Nitrate (NO_3-N)	0	0	0.1	0.1	0.2	0.2	0.5	0.5
Orthophosphate (o-PO_4-P)	0	0	0.1	0.1	0.2	0.2	0.5	0.5
Sulfate (SO_4)	0	0	0.1	0.1	0.2	0.2	0.5	0.5
Iodide (I)	0	0	0.1	0.1	0.2	0.2	0.5	0.5
	Std (ml)	Conc (mg/L)	10 mg/L Std (ml)	Conc (mg/L)	10 mg/L Std (ml)	Conc (mg/L)	10 mg/L (ml)	Conc (mg/L)
Bromate(BrO_3)	0	0	0.1	0.010	0.2	0.02	0.5	0.05

9.4. **Initial Calibration Verification (ICV)**

9.4.1. Purchase a certified secondary source. This standard is also used as Lab Control Standard.

9.5. **Daily Continuing Calibration (DCC)**

9.5.1. Prepare daily continuing calibration standard from the primary stock standard. This solution is use for continuing calibration check (CCC) and ending calibration check (ECC). All calibration checks are followed by calibration blank (CB).

10.0 PROCEDURES

10.1. **Sample Preparation**

10.1.1. Water Samples

10.1.1.1. Identify the samples for the preparation batch and input them in the sequence table.

10.1.1.2. Withdraw the samples from the sample control room and allow the samples to equilibrate to room temperature.

10.1.1.3. Using a 10 ml plastic syringe, withdraw 10 ml of sample and attach the 0.22 µm filter. Discard the first 2 ml and collect the rest on a properly labeled sample container.

10.1.1.4. Repeat step 10.1.3 for all samples. Do the same for the MB and LCS using reagent water.

10.1.1.5. Take clean sample vials equal to the number of samples to be analyzed not to exceed 20 field samples. If number of samples are ≤ 10 add vials for IPCs, MB, LCS, and MS, If samples > 10 add three more vials for CCV, CCB, and MS.

10.1.1.6. Transfer approximately 10 ml of sample into the sample vials, reagent water for MB and LCS.

10.1.1.7. Spike LCS and MS designated vials with LCS/MS spike standard.

10.1.2. Soil Samples

10.1.2.1. Allow sample to equilibrate at room temperature.

10.1.2.2. Mix sample thoroughly discarding artifacts, e.g. vegetation, rocks, etc.

10.1.2.3. Tare a 125 ml polyethylene bottle to nearest 0.1 gm.

10.1.2.4. Weigh 10 gm of mixed soil sample to the nearest 0.1 gm.

10.1.2.5. Using a graduated cylinder, add 100 ml of reagent water to the bottle. Place the bottle in a shaker and mix the solution for 10 minutes.

10.1.2.6. Remove bottles from the shaker and centrifuge the slurry for 15-30 minutes or allow the particles to settle.

10.1.2.7. Treat the liquid phase like an aqueous sample and follow 10.1.1.3 to 10.1.1.6.

10.2. **Instrument Parameters**

	D0	D7	E3
Instrument	Metrohm		
Detector	Conductivity		
Column	Metrosep A Supp 5 (100/4.0 mm)	Metrosep A Supp 5 (150/4.0 mm)	Metrosep A Supt 250x4.0 mm
Sample Flow Rate	0.70 ml/min	0.75 ml/min	0.8 ml/min
Pump Pressure (Mpa)	5.0-6.0	6.5-7.5	9.5-10.5
Sample Loop	20 µL		
Run Time	w/o I= 14.0 min; w/ I= 19min.	w/o I= 16.0 min; w/ I= 25min.	30 min
Scale Setting (µS)	1000	100	2 µS/cm
Oven Temp	45°C for Bromate only		

10.3. **Calibration**

10.3.1. Instrument Set Up

10.3.1.1. Set up the Metrohm IC with the proper operation parameter established in Section 10.2.

10.3.1.2. Prime the pump to eliminate air bubbles in the system.

10.3.1.3. Step the suppressor thrice and equilibrate the column for 30 minutes or until stable baseline is obtained.

10.3.2. Initial Calibration (CAL)

10.4.3.1 Prepare initial calibration solution as described in section 9.3.1.

10.3.2.1. Analyze the ICAL as described in section 10.4.

10.3.2.2. Refer to section 10.5 for calculations.

10.3.2.3. Check Appendix 1 for acceptance criteria.

10.3.2.4. If the correlation coefficient (r) is out of acceptance criteria, check the results again and identify which one is off.

10.3.2.4.1. If the highest ICAL point appears to be bias high, exclude the highest point.

10.3.3. Initial Calibration Verification (ICV)

10.3.3.1. Analyze ICV spiked with QCS after the initial calibration to verify the validity of the initial calibration and every 3 months thereafter.

10.3.4. Retention Rime Window (RTW)

10.3.4.1. After initial calibration, establish a tentative retention time window based from the calibration points.

10.3.4.2. Tabulate the retention time for each analyte and calculate their standard deviations. Retention time window is determined by ± 3 X standard deviation.

10.3.4.3. Determine actual retention time window from the continuing calibrations within the course of a day. RTW is determined by 3X standard deviation of retention time for each analyte.

10.3.5. Daily Continuing Calibration (DCC)

10.3.5.1. Analyze initial calibration check standard and initial calibration blank (ICC/ICB) at the beginning of analytical sequence.

10.3.5.2. Analyze continuing calibration check standard (CCC) after every 10 samples or whenever the anion eluent is changed or as per project requirements.

10.3.5.3. Analyze ending calibration check standard (ECC) at the end of each analytical sequence of a 24-hour shift.

10.3.5.4. Refer to Appendix 1 for acceptance criteria and corrective action.

10.4. **Analysis**

10.4.1. Analytical Sequence

10.4.1.1. ICV – initial calibration check

10.4.1.2. ICB – initial calibration blank (reagent water)

10.4.1.3. MB – lab reagent blank

10.4.1.4. LCS – lab control sample

10.4.1.5. MS –matrix spike sample

10.4.1.6. Samples – maximum of 10 field samples

10.4.1.7. CCV – continuing calibration check

10.4.1.8. CCB – continuing calibration blank

10.4.1.9. MSD – another lab fortified matrix spike sample

10.4.1.10. Samples – maximum of 10 field samples

10.4.1.11. ECC – ending calibration check

10.4.2. Sample Result Evaluation

10.5.4.1 Check that ICV, MB and LCS are within the control limits. Refer to Appendix 1 for acceptance criteria and corrective action.

- Check the MB for absence or presence of contamination.
- Check the LCS for method performance.
- Check the MS for absence or presence of matrix interference.

10.5.4.2 Qualitatively identify detected analytes using the actual retention time window. Check that the retention time for all positive results fall within the actual RTW as described in 10.3.5.3.

10.5.4.3 Check the peaks for all positive results. Refer to Figure 1 for typical peak evaluation.

- The same peak integration technique applied in the initial calibration must be applied during the analysis of field samples.
- Peaks must be well resolved and properly integrated.
- If manual integration is necessary, retain the original chromatogram, and the corrected chromatogram must be initialed and dated by the analyst and the supervisor.
- If a peak appears to be cryptic/anomalous, consult the supervisor.

10.5.4.4 Check that results exceeding calibration range are appropriately diluted and re-analyzed bringing the concentration to be within the calibration range.

10.5.4.5 Rule-out any suspicion of carry-over. Re-analyze any sample with trace amount of analyte(s) seen in a previous sample that exceeds the calibration range.

10.5. **Calculations**

10.5.1. For water or soil samples, if the initial sample taken was V_i (ml,g) and diluted to V_f (ml), then calculate the concentration using the following equation:

$$Cw = (Ci)(DF) \qquad \text{Eq.-10.5.1}$$

where:

Ci – Computer generated concentration in diluted digestate, in mg/L

Cw - Concentration in original sample, in mg/L

DF - $=V_f/V_i$ =Dilution factor

V_i - Initial volume of the diluted sample, in mL

V_f - Final volume of diluted samples, in mL

10.5.2. Calculate for Percent Recovery of LCS

$$\% R = \left[\frac{C_f}{C_o}\right] 100 \qquad \text{Eq.-10.5.2}$$

where:

%R - is the percent recovery

C_f *- is the concentration found*

C_o *- is the known concentration of spiked solution*

10.5.3. Calculate for Percent Recovery of MS

$$\% R = \left[\frac{(C_f - C_s)}{C_o}\right] 100 \qquad \text{Eq.-10.5.3}$$

where:

%R - is the percent recovery

C_f *- is the concentration found*

C_s *- is the concentration of the sample*

C_o *- is the known concentration of spiked solution*

10.5.4. Calculate for Precision

$$RPD = \frac{\left|C_1 - C_2\right|}{\left(\frac{C_1 + C_2}{2}\right)} \times 100 \qquad \text{Eq.-10.5.4}$$

where:

RPD - is the relative percent recovery

R_1 *- is the result of the first measurement*

R_2 *- is the result of the second measurement*

R_{ave} *- is the average of first and second measurements*

10.6. **Data Reduction**

10.6.1. Make a copy of the analytical run log and sample preparation log.

10.6.2. Highlight the data to be reported.

10.6.3. Print a copy of the raw data and the QC report.

10.6.4. Keep all other data generated with the analytical folder marked with “For record only”.

10.7. **Report Generation**

10.7.1. Generate the method.txt file using WDBX[1].exe.

10.7.2. Generate the sample results using and MSRBX[1].exe.

10.7.3. Generate the LCS and MS summary using QCIC.exe.

10.7.4. Generate Sample Duplicate summary using CQ1N.exe.

10.7.5. Generate the case narrative using CN2.exe.

10.8. **Data Review**

10.8.1. Arrange the analysis package in sequence as detailed below using section separators. Attach all raw data to every form generated, to include manual integration(s) and re-analyses.

10.8.1.1. Case Narrative

10.8.1.2. Sample Results

10.8.1.3. LCS/LCSD Summary

10.8.1.4. MS/MSD Summary

10.8.1.5. ICAL Summary

10.8.1.6. ICV Summary

10.8.1.7. DCC Summary

10.8.1.8. Analytical Log

10.8.1.9. Sample Preparation Log

10.8.1.10. Non-Conformance Report

10.8.2. Perform a 100% data review in accordance to EMAX-DM01 and the PSR.

10.8.3. Check that identifications are done properly.

10.8.4. Check that sample results are integrated properly and results over calibration range are diluted and re-analyzed within calibration range.

10.8.5. Check that presence of saturated peak(s) are diluted, and quantitated properly.

10.8.6. Check that suspected carry-overs are confirmed.

10.8.7. Check the generated reports against the raw data.

10.8.8. Review the case narrative and edit as necessary to reflect essential issues not captured by the case narrative generator program.

10.8.9. Submit the analysis package for secondary review.

10.9. **Preventive Maintenance**

10.9.1. Perform daily instrument check prior to sample analysis. Refer to Form 300FM – Instrument Maintenance Log.

Maintenance Activity	Description	Frequency
Verification	Prime system and run test injection Clean and inspect sampler and perform pressure test	Daily prior to analysis

X[1] - version number

Detector Maintenance	Inspect flow cell for leaks and verify performance	Daily prior to analysis
Documentation	Record all instrument maintenance performed in the instrument maintenance log.	Daily prior to analysis
IC Pump Maintenance	Replace pump head seal, purge valve seal, and filter assembly frits. Perform wear-in procedure and leak test	Every six months or as necessary
Column Maintenance	Replace column or flush column as necessary. Perform pressure test.	As necessary
Valve Maintenance	Replace rotor seal. Inspect valve fittings and capillaries for leaks	As necessary
System Cleaning	Remove dust from fans and vent covers	Every 6 months or as necessary
Sampler Maintenance	Replace tubing. Lubricate moving parts.	Once a year or as necessary
Inspection	Perform general inspection of the complete system	Once a year

10.9.2. Maintain an inventory of instrument parts and supplies for routinely maintenance.

11.0 QUALITY CONTROL

11.1. Refer to Appendix 1 for all related Quality Control parameters, frequency, acceptance criteria and corrective action.

11.2. Assessing Analytical QC. Every analytical batch shall consist of complying to the requirement of the following:

- Continuing Calibration Verification (CCV)
- Method Blank (MB)
- Lab Control Sample (LCS)

11.3. Assessing Analyte Recovery Data Quality on a given matrix shall be demonstrated for each group of sample with similar matrix and shall consist of complying to the requirement of the following:

- Matrix Spike (MS)
- MS spike level must be high enough to be detected above the original sample and should not be less than 4 times the MDL.
- If the concentration of fortification is less than 25% of the background concentrations measured in the unfortified sample, the matrix recovery should not be calculated.
- If recovery for MS falls outside the recovery range and the LCS is within control, the recovery problem for MS is judged to be matrix related not system related.
- All analysts conducting this analysis must have established Demonstration of Capability (DOC) as described in EMAX-QA05.

12.0 CORRECTIVE ACTION

12.1. Implement corrective action as described in Appendix 1.

12.2. **Sample Preparation QC**

12.2.1. For insufficient amount of sample, initiate a NCR and inform the PM immediately.

12.2.2. When laboratory reagent blank is non-compliant, investigate the source of the problem and institute resolution to correct, minimize or eliminate the problem.

12.2.3. If the analyte found in the laboratory reagent blank is not detected in any of the field samples, consult with the Supervisor and the PM if the result can be reported. Otherwise, re-analyzed the method blank with the associated samples.

12.2.4. If the reagents that did not undergo quality control check were accidentally used, consider the following to correct the problem.

- Check that there was no data integrity impact. Otherwise, repeat the analysis of all associated samples with new QC samples using QC'd reagent.
- If method blank is clean, use that data to document the reagent QC.

12.3. **Sample Analysis QC**

12.3.1. When Instrument Performance Check (IPC) is non-compliant and all measures (e.g. flushing the column and/or changing the column, etc.) had been undertaken to correct the problem, consult the Supervisor for further advice prior to performing a new ICAL.

12.3.2. When flushing does not get rid of carry-over, consider changing the column.

12.3.3. If the reagent water shows contamination in the instrument or in the laboratory reagent blank consider changing the filters of the reagent water source.

12.3.4. If the QC'd blank soil shows contamination in the laboratory reagent blank, consider baking the soil at 400°C overnight then re-QC prior to its use. If problem persist, discontinue the use of the lot and use a new QC'd lot.

12.4. **Method QC**

12.4.1. When MDL verification is non-compliant, consider instrument maintenance and/or repeating the MDL study.

12.4.2. When retention time significantly shifts, check for any bubbles or leaks.

12.5. Non-Conformance Report (NCR). Refer to EMAX-QA08 for details.

12.5.1. NCR is required when the following circumstances occur:

- Anomaly other than specified in Appendix 1 is observed.
- Sample is out of technical holding time.

13.0 POLLUTION PREVENTION

13.1. Quantity of chemicals purchased should be based on expected usage during its shelf life to minimize disposal of unused material.

13.2. Actual reagent preparation volumes should reflect anticipated usage and reagent stability.

13.3. Observe all necessary precautions to avoid spillage of reagents that may go to the wastewater drains.

14.0 WASTE MANAGEMENT

14.1. All waste generated during this analytical process shall be placed in a properly labeled waste containers. These wastes are picked up by the waste disposal section for proper disposal.

15.0 SUPPLEMENTARY NOTES

15.1. **Definition of Terms**

15.1.1. Analyte – The specific chemicals or components for which a sample is analyzed; may be a group of chemicals that belong to the same chemical family, and which are analyzed together.

15.1.2. Reagent Water – is purified water free from any target analyte or any other substance that may interfere with the analytical process.

15.1.3. Batch – is a group of samples that are prepared and/or analyzed at the same time using the same lot of reagents.

15.1.3.1. Analytical batch - is composed of a complete analysis for a batch of no more than 20 field samples. Every 10 field samples or a fraction thereof shall be bracketed with continuing calibration and one MS is analyzed. For every analytical batch at least one MB and one LCS is analyzed.

15.1.3.2. Preparation batch - is composed of one to 20 samples of the same matrix, a method blank, a lab control sample and matrix spike/matrix spike duplicate.

15.1.4. Detection Limit (DL) – The lowest concentration or amount of the target analyte that can be identified, measured and reported with confidence that the analyte concentration is not a false positive.

15.1.5. Limit of Detection (LOD) – An estimate of the minimum amount of substance that an analytical process can reliably detect.

15.1.6. Limit of Quantitation (LOQ) – The minimum levels, concentrations or quantities of target variable (e.g., target analyte) that can be reported with a specified degree of confidence.

15.1.7. Material Safety Data Sheet (MSDS) – is where the physical data, toxicology and safety precaution of a certain substance is listed.

15.1.8. Calibration – is a determinant measured from a standard to obtain the correct value of an instrument output.

15.1.9. Instrument Blank – is a target-analyte-free solvent subjected to the entire analytical process to establish zero baseline or background value.

15.1.10. Method Blank (MB) – is a target-analyte-free sample spiked with a verified known amount of target analyte(s) or a reference material with a certified known value subjected to the entire sample preparation and/or analytical process. LFB is analyzed to monitor the accuracy of the analytical system.

15.1.11. Lab Control Sample (LCS) – is a target-analyte-free sample spiked with a verified known amount of target analyte(s) or a reference material with a certified known value subjected to the entire sample preparation and/or analytical process. LCS is analyzed to monitor the accuracy of the analytical system.

15.1.12. Lab Control Sample Duplicate (LCSD) – is a replicate of LCS analyzed to monitor precision in the absence of MS/MSD sample.

15.1.13. Sample – is a specimen received in the laboratory bearing a sample label traceable to the accompanying COC. Samples collected in different containers having the same field sample ID are considered the same and therefore labeled with the same lab sample ID unless otherwise specified by the project.

15.1.14. Sample Duplicate – is a replicate of a sub-sample taken from one sample, prepared and analyzed within the same preparation batch.

15.1.15. Sub-sample – is an aliquot taken from a sample for analysis. Each sub-sample is uniquely identified by the sample preparation ID.

15.1.16. Matrix – is a component or form of a sample.

15.1.17. Matrix Spike (MS) – is a sample spiked with a verified known amount of target analyte(s) subjected to the entire sample preparation and/or analytical process. MS is analyzed to monitor matrix effect on a method's recovery efficiency.

15.1.18. Matrix Spike Duplicate (MSD) – is a replicate of MS analyzed to monitor precision or recovery.

15.1.19. Instrument Performance Check (IPC) – is a mid-range check standard containing the target analytes that is analyzed to verify the instrument calibration at the given criteria.

15.1.20. Quality Control Sample (QCS) – A solution obtained from a secondary source different from the source of calibration standard with known concentration of method analytes that is use to fortify an aliquot of ICV, MB or LCS.

15.1.21. Raw Data - Any original factual information from a measurement activity or study recorded in a laboratory notebook, worksheets, records, memoranda, notes, or exact copies thereof that are necessary for the reconstruction and evaluation of the report of the activity or study. Raw data may include photography, microfilm or microfiche copies, computer printouts, magnetic media, including dictated observations, and recorded data from automated instruments. If exact copies of raw data have been prepared (e.g., tapes which have been transcribed verbatim, data and verified accurate by signature), the exact copy or exact transcript may be submitted.

15.1.22. Non-conformance - An indication or judgment that a product or service has not met the requirements of the relevant specifications, contract or regulation; also the state of failing to meet the requirements.

15.1.23. Corrective Action - Action taken to eliminate the causes of an existing nonconformity, defect or other undesirable situation in order to prevent recurrence.

15.2. **Application of EMAX QC Procedures**

15.2.1. The procedures and QC criteria summarized in this SOP shall be applied to all projects when performing Ion Chromatography analysis unless. In instances where there is a project or program QAPP, the requirements given in the project shall take precedence over this SOP.

15.3. **Department of Defense (DoD) Projects**

15.3.1. Samples from DoD sponsored projects shall follow the Quality Assurance Project Plan (QAPP), Statement of Work (SOW) and/or client's quality control directive. In the absence of QAPP, the DoD Quality Systems Manual (QSM), latest update, shall be applied.

15.4. **Department of Energy Basic Ordering Agreement (DoE-BoA) Projects**

15.4.1. Samples from DoE sponsored projects shall follow the Quality Assurance Project Plan (QAPP), Statement of Work (SOW) and/or client's quality control directive. In the absence of QAPP, the DoE Quality Systems for Analytical Services (QSAS), latest update, shall be applied.

16.0 REFERENCES

16.1. Method 300.0 Rev. 2.1, Methods for Determination of Inorganic Substances in Environmental Samples - EPA/600/R-93/100.

16.2. EMAX Quality Systems Manual, as updated.

17.0 APPENDICES

17.1. **Tables**

17.1.1. Table 1 Established Limits

17.2. **Figures**

17.2.1. Figure 1 Typical Peak Evaluation

17.2.2. Figure 2A Typical Chromatogram

17.2.3. Figure 2B Typical Bromate Chromatogram

17.2.4. Figure 3 Typical Sample Result Summary

17.2.5. Figure 4 Typical LCS/LCSD Summary

17.2.6. Figure 5 Typical MS/MSD Summary

17.2.7. Figure 6 Typical Case Narrative

17.3. **Appendices**

17.3.1. Appendix 1 Summary of Quality Control Procedures

17.3.2. Appendix 2 Demonstration of Capability

17.4. **Forms**

17.4.1. 300FS Sample Preparation Log

17.4.2. 300FA Analytical Run Log

17.4.3. 300FM Instrument Maintenance Log

Table 1: ESTABLISHED LIMITS

PARAMETER	WATER (mg/L)			SOIL (mg/Kg)		
	DL	LOD	LOQ	DL	LOD	LOQ
Bromide	0.125	0.25	0.5	1.25	2.5	5
Chloride	0.05	0.1	0.2	0.5	1	2
Fluoride	0.025	0.05	0.1	0.25	0.5	1
Nitrate	0.025	0.05	0.1	0.25	0.5	1
Nitrite	0.025	0.05	0.1	0.25	0.5	1
Phosphate	0.125	0.25	0.5	1.25	2.5	5
Sulfate	0.125	0.25	0.5	1.25	2.5	5
PARAMETER	**WATER (µg/L)**			**SOIL (µg/Kg)**		
	DL	**LOD**	**LOQ**	**DL**	**LOD**	**LOQ**
Bromate	2.5	5	10	N/A	N/A	N/A

Figure 1: TYPICAL PEAK EVALUATION

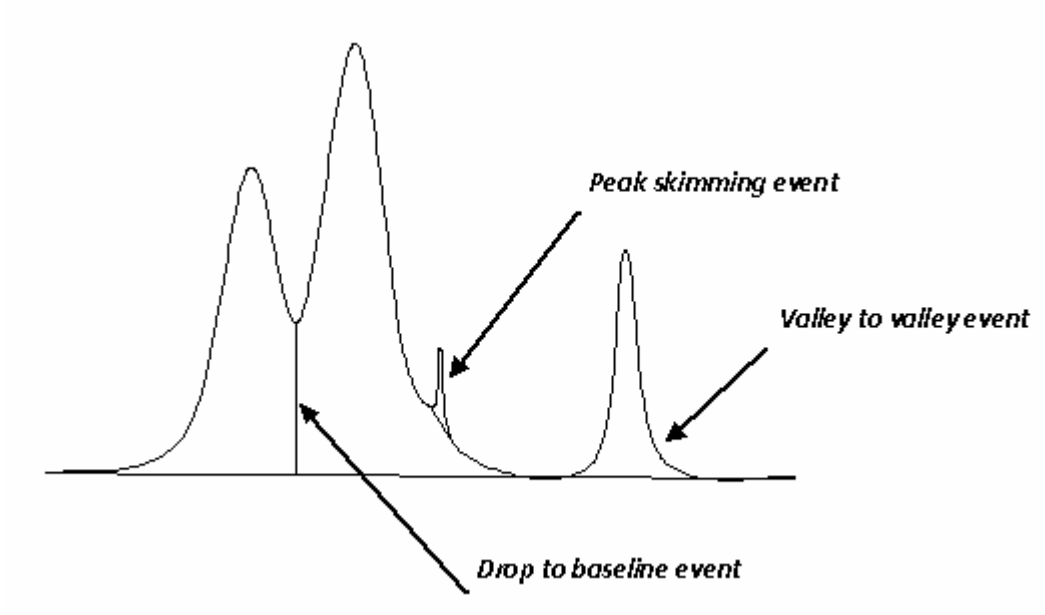


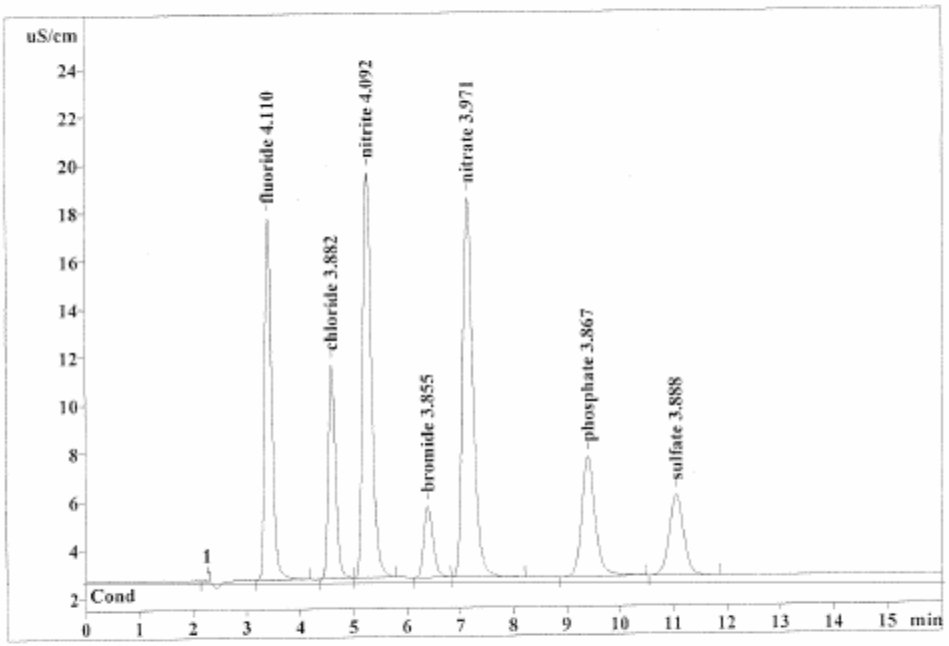
Figure 2A: TYPICAL CHROMATOGRAM

Report date: 11/24/2010 9:04:00 AM
Printed by: Jadelyn Chun

Ident: AK21-11 ICV
Analysis from: 11/23/2010 7:46:41 PM
File: ub231946.chw Last save: 11/24/2010 8:57:24 AM

Method: IC100-K23.mtw Last save: 11/23/2010 6:13:45 PM
Run operator: Jadelyn Chun
Analysis number: 59508

SAMPLE:
:
Vial number: 11
Volume: 1.0 µL
Dilution: 1.00
Amount: 1.0000



Quantitation method: Custom

No	Retention min	Height uS/cm	Area uS/cm*sec	Conc. mg/L	Name
1	2.27	0.01	0.056	0.000	
2	3.41	15.00	138.433	4.110	fluoride ✓
3	4.60	8.87	82.735	3.882	chloride ✓
4	5.26	16.82	194.691	4.092	nitrite ✓
5	6.40	2.93	35.849	3.855	bromide ✓
6	7.15	15.77	213.470	3.971	nitrate ✓
7	9.41	4.96	87.594	3.867	phosphate ✓
8	11.07	3.33	61.691	3.888	sulfate ✓
8	16.00	67.68	814.518	27.664	

This report has been created by IC Net
METROHM LTD

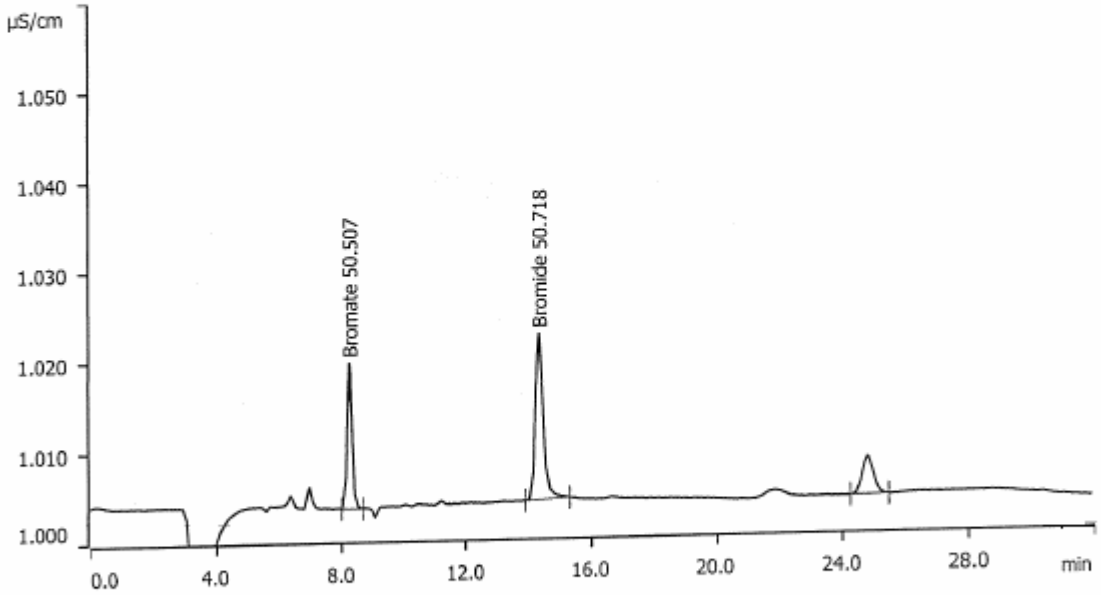
Figure 2B: TYPICAL BROMATE CHROMATOGRAM

Mag - Net 2010-08-06 4:48:31

Sample data

Sequence E3H05-15
Ident . . . . . ICV ✓
Determination start 2010-08-05 21:48:56 UTC-7
Method . . . . . E3H0510 METHOD
Sample type . . . . . Check standard 1
Dilution Factor 1
Operator . . . . . Andy Mai

Anions



Peak number	Retention time min	Area (µS/cm) x min	Height µS/cm	Component name	Concentration ppb
1	8.245	0.002721	0.016	Bromate	50.507 ✓
2	14.320	0.005177	0.018	Bromide	50.718
3	24.777	0.001756	0.004		invalid

Figure 3: **TYPICAL SAMPLE RESULT SUMMARY**

METHOD E300.0
NITRATE

Client : XYZ, INC.
Project : CLEAN PROJECT
Batch No. : 10I285

Matrix : WATER
Instrument ID : I100

SAMPLE ID	EMAX SAMPLE ID	RESULTS (mg/L)	DLF	MOIST	LOQ (mg/L)	LOD (mg/L)	Analysis DATETIME	Extraction DATETIME	LFID	CAL REF	PREP BATCH	Collection DATETIME	Received DATETIME
MBLK1W	ICI055WB	ND	1	NA	0.100	0.0500	09/20/1022:25	NA	AI25-36	AI25-34	ICI055W	NA	NA
LCS1W	ICI055WL	1.90	1	NA	0.100	0.0500	09/20/1022:41	NA	AI25-37	AI25-34	ICI055W	NA	NA
LCD1W	ICI055WC	1.90	1	NA	0.100	0.0500	09/20/1022:57	NA	AI25-38	AI25-34	ICI055W	NA	NA
CDS1MW01S-063	I285-02	16.6	10	NA	1.00	0.500	09/20/1023:13	NA	AI25-39	AI25-34	ICI055W	09/20/1008:24	09/20/10
CDS1MW01S-063DUP	I285-02D	16.6	10	NA	1.00	0.500	09/20/1023:30	NA	AI25-40	AI25-34	ICI055W	09/20/1008:24	09/20/10
CDS1MW01S-063MS	I285-02M	35.9	10	NA	1.00	0.500	09/20/1023:46	NA	AI25-41	AI25-34	ICI055W	09/20/1008:24	09/20/10
CDS1MW01S-063MSD	I285-02S	35.9	10	NA	1.00	0.500	09/21/1000:02	NA	AI25-42	AI25-34	ICI055W	09/20/1008:24	09/20/10
MPMW07S-060	I285-03	14.5	10	NA	1.00	0.500	09/21/1001:39	NA	AI25-48	AI25-46	ICI055W	09/20/1009:42	09/20/10
MPMW04S-059	I285-04	0.0595J	1	NA	0.100	0.0500	09/21/1001:55	NA	AI25-49	AI25-46	ICI055W	09/20/1010:25	09/20/10
MPMW08S-061	I285-06	11.1	5	NA	0.500	0.250	09/21/1002:11	NA	AI25-50	AI25-46	ICI055W	09/20/1011:18	09/20/10
MPMW09S-062	I285-07	0.494	1	NA	0.100	0.0500	09/21/1002:27	NA	AI25-51	AI25-46	ICI055W	09/20/1012:09	09/20/10
CDS1MW02S-064	I285-08	13.8	5	NA	0.500	0.250	09/21/1002:44	NA	AI25-52	AI25-46	ICI055W	09/20/1013:09	09/20/10
I005MW03S-054	I285-09	4.66	1	NA	0.100	0.0500	09/21/1003:00	NA	AI25-53	AI25-46	ICI055W	09/20/1014:01	09/20/10

Figure 4: **TYPICAL LCS/LCSD SUMMARY**

EMAX QUALITY CONTROL DATA
LCS/LCD ANALYSIS

CLIENT: XYZ, INC.
PROJECT: CLEAN PROJECT
BATCH NO.: 10I285
METHOD: METHOD E300.0

MATRIX:	WATER			% MOISTURE:	NA
DILUTION FACTOR:	1	1	1		
SAMPLE ID:	MBLK1W				
LAB SAMP ID:	ICI055WB	ICI055WL	ICI055WC		
LAB FILE ID:	AI25-36	AI25-37	AI25-38		
DATE EXTRACTED:	NA	NA	NA	DATE COLLECTED:	NA
DATE ANALYZED:	09/20/1022:25	09/20/1022:41	09/20/1022:57	DATE RECEIVED:	NA
PREP. BATCH:	ICI055W	ICI055W	ICI055W		
CALIB. REF:	AI25-34	AI25-34	AI25-34		

ACCESSION:

PARAMETER	BLNK RSLT (mg/L)	SPIKE AMT (mg/L)	BS RSLT (mg/L)	BS % REC	SPIKE AMT (mg/L)	BSD RSLT (mg/L)	BSD % REC	RPD (%)	QC LIMIT (%)	MAX RPD (%)
Nitrate	ND	2.00	1.90	95	2.00	1.90	95	0	90-110	20

Figure 5: **TYPICAL MS/MSD SUMMARY**

EMAX QUALITY CONTROL DATA
MS/MSD ANALYSIS

CLIENT: XYZ, INC.
PROJECT: CLEAN PROJECT
BATCH NO.: 10I285
METHOD: METHOD E300.0

MATRIX:	WATER			% MOISTURE:	NA
DILUTION FACTOR:	10	10	10		
SAMPLE ID:	CDS1MW01S-063				
LAB SAMP ID:	I285-02	I285-02M	I285-02S		
LAB FILE ID:	AI25-39	AI25-41	AI25-42		
DATE EXTRACTED:	NA	NA	NA	DATE COLLECTED:	09/20/10 08:24
DATE ANALYZED:	09/20/1023:13	09/20/1023:46	09/21/1000:02	DATE RECEIVED:	09/20/10
PREP. BATCH:	ICI055W	ICI055W	ICI055W		
CALIB. REF:	AI25-34	AI25-34	AI25-34		

ACCESSION:

PARAMETER	SMPL RSLT (mg/L)	SPIKE AMT (mg/L)	MS RSLT (mg/L)	MS % REC	SPIKE AMT (mg/L)	MSD RSLT (mg/L)	MSD % REC	RPD (%)	QC LIMIT (%)	MAX RPD (%)
Nitrate	16.6	20.0	35.9	97	20.0	35.9	96	0	80-120	20

Figure 6: TYPICAL CASE NARRATIVE

CASE NARRATIVE

Client : XYZ, INC.

Project : CLEAN PROJECT

SDG : 10I285

METHOD E300.0
ANIONS BY IC

A total of seven (7) water samples were received on 09/20/10 for Anions by IC analysis, Method E300.0 in accordance with Methods for the Determination of Inorganic Substances in Environmental Samples (EPA/600/R-93/100).

Holding Time
Samples were analyzed within the prescribed holding time.

Calibration
Multi-calibration points were generated to establish initial calibration (ICAL). ICAL was verified using a secondary source. Continuing calibration verifications were carried out at the frequency specified by the project. All calibration requirements were within acceptance criteria.

Method Blank
Method blank was analyzed at the frequency required by the project. For this SDG, one method blank was analyzed with the samples. Result was compliant to project requirement.

Lab Control Sample
A set of LCS/LCD was analyzed with the samples in this SDG.
Percent recoveries for ICI055WL/C were all within QC limits.

Matrix QC Sample
Matrix QC sample was analyzed at the frequency prescribed by the project.
Percent recoveries for I285-02M/S were within project QC limits.
Sample duplicate was also analyzed with the samples. RPD was within project limit.

Sample Analysis
Samples were analyzed according to prescribed analytical procedures. All project requirements were met otherwise anomalies were discussed within the associated QC parameter.

Appendix 1: SUMMARY OF QUALITY CONTROL PROCEDURES

QC PROCEDURE	FREQUENCY	ACCEPTANCE CRITERIA	CORRECTIVE ACTION	1st Rvw	2nd Rvw
Initial Calibration Min. 3 pts + CB	Every 6 months or when CCV fails to meet the acceptance criteria.	Correlation coefficient ≥ 0.995 for linear regression	Correct the problem then repeat initial calibration		
Initial Calibration Verification (ICV)	After every initial calibration and every 3 months.	All analytes within ± 10% of expected value	Correct the problem then repeat initial calibration		
Continuing Calibration Verification (CCV)	At the beginning of analytical batch and every 10 samples there after and at the end of the sequence.	All analytes within ± 10% of expected value.	Re-analyze DCC. If re-analysis is still outside acceptance limits, discontinue the analysis. Resolve the cause of failure and re-calibrate prior to resuming analysis.		
Method Blank (MB)	One per preparation batch	No analytes detected > ½ LOQ. Blank result must not affect sample results.	Re-prep and re-analyze MB and all samples processed with MB.		
Lab Control Sample (LCS)	One LCS per preparation batch	All analytes within ± 10% of expected value.	Re-prep and re-analyze the LCS and all associated samples		
Matrix Spike (MS)	One per analytical batch unless specified by the project.	All analytes within project QC Limits or within ± 20% of expected value.	If LCS passed, no action.		
Comments: For flagging criteria refer to PSR.			Reviewed By		
			Date		

Appendix 2: DEMONSTRATION OF CAPABILITY

DEMONSTRATION OF CAPABILITY
METHOD: EPA 300.0

SOP: EMAX-300.0
Conc Unit: mg/L
Sample Amount(ml): 1

Extracted date: 6/21/2010
Analyzed date: 6/21/2010
Analyzed by: Jadelyn Chun

PARAMETER	ICF039WL AF31-04	ICF039WC AF31-05	ICF041WL AF31-06	ICF041WC AF31-07	TV	Ave. Conc.	Ave. %Rec	SD	RSD	QC Criteria	COMMENTS
Flouride	2.05	2.05	2.05	2.05	2	2.1	103	0.002	0.1	90 - 110	Passed
Chloride	5.48	5.47	5.47	5.45	5	5.5	109	0.009	0.2	90 - 110	Passed
Nitrite-N	2.13	2.13	2.13	2.13	2	2.1	106	0.001	0.0	90 - 110	Passed
Bromide	5.03	5.04	5.04	5.03	5	5.0	101	0.004	0.1	90 - 110	Passed
Nitrate-N	2.00	2.00	2.00	2.00	2	2.0	100	0.002	0.1	90 - 110	Passed
Phosphate-P	5.21	5.22	5.22	5.21	5	5.2	104	0.005	0.1	90 - 110	Passed
Sulfate	4.85	4.86	4.86	4.85	5	4.9	97	0.005	0.1	90 - 110	Passed

SOP: EMAX-300
Conc Unit: ug/L
Sample Amount(ml): 1

Extracted date: 6/23/2010
Analyzed date: 6/23/2010
Analyzed by: Andy Mai

PARAMETER	BCF003WL E3F23-12	BCF003WC E3F23-13	BCF004WL E3F23-14	BCF004WC E3F23-15	TV	Ave. Conc.	Ave. %Rec	SD	RSD	QC Criteria	COMMENTS
Bromate	101.1	101.5	101.4	101.2	100	101.3	101	0.194	0.2	90 - 110	Passed

300FS: SAMPLE PREPARATION LOG

EMAX LABORATORIES, INC.

FileID: IC.xls

PREPARATION LOG FOR ANIONS (SOIL)

PrepBatchID	LabSampleID	Aliquot	Unit	DateTime	FinalVol(ml)	ExpAmt	ExpVf(ml)	PrepFctr	Comments

PrepFctr=(ExpAmt/Aliquot)*(Vf/ExpVf)

Comments:

Prepared By:

Checked By:

Date

300FA: **ANALYTICAL RUN LOG**

EMAX LABORATORIES, INC.

ANALYSIS RUN LOG
for
ION CHROMATOGRAPHY

Page 1

Note: For samples and relevant QCs/Standards analyzed, refer to attached analytical sequence.

Comments:

Book #:	AD0-032
Instrument No.:	D0
Pipette ID's:	039380124
	SW8A-02-12
	SW8A-02-13
Balance ID#:	40706360
Analytical Sequence:	
Method File:	
Analytical Batch:	

SOP #	Rev. #
☐ EMAX-300.0	
☐ EMAX-4110B	
☐ EMAX-9056	
☐ EMAX-	

STANDARDS ID	
ICAL	
ICV	
CCV	
LCS	
MS	

Column: Metrosep A Supp 5-100

Flow Rate: 0.70 ml/min

IC Eluent:

(320 mM Na_2CO_3 / 100 mM $NaHCO_3$) 20 ml - 2 L

IC Regenerant:

(1000 mM H_2SO_4) 100 ml - 1 L

ELECTRONIC DATA ARCHIVAL	
Location	Date
☐ IC-METROHM	
☐	

Analyzed By:

Date:

300FM: INSTRUMENT MAINTENANCE LOG

EMAX LABORATORIES, INC.

Page 1

INSTRUMENT MAINTENANCE LOG FOR IC

Instrument No: 100 Month: Year: 20__ Book #: M100-003

Date							
Background Noise (<0.01)							
Check Eluent bottle level							
Check DI bottle level							
Check H_2SO_4 bottle level							
Check autosampler rinse beakers							
Pump Setting at 0.7ml/min							
Pump Pressure (4.5-6.5mpa)							
µS Reading							
Autosampler Filter							
Printer Paper							
Computer Clock							
Analyst Initial							
Troubleshooting							
Problem(s) Encountered							
Return To Specs (Analyst Initial)							

Code	Problems Encountered	Code	Corrective Action

Reviewed by: _____

STANDARD OPERATING PROCEDURE

ALKALINITY

SOP No.:	EMAX-310.1	Revision No.	5	Effective Date:	17-Oct-11
Prepared By:	Mary Jane Mendoza			Date:	10.13.11
Approved By:	Kenette Pimentel QA Manager			Date:	10·13·11
Approved By:	Caspar Pang Laboratory Director			Date:	10-13-11

Control Number: 310.1-05-

1.0 SCOPE AND APPLICATION

1.1. This method is used to measure alkalinity of aqueous samples by titration. This is applicable to drinking, surface, and saline waters, domestic and industrial wastes. It is suitable for all concentration ranges of alkalinity; however, appropriate aliquots should be used to avoid a titration volume greater than 50 ml.

1.2. Alkalinity of soil may also be determined by leaching the matrix with reagent water and analyzing the leachate for alkalinity.

1.3. This SOP is an adaptation of EPA Method 310.1.

2.0 SUMMARY OF METHOD

2.1. An unaltered amount of sample is titrated with standard acid titrant to an end point of pH=4.5.

2.2. Solid matrices are leached with reagent water prior to titration.

2.3. **Interferences**

2.3.1. Substances, such as salts of weak organic or inorganic acids present in large amounts, may cause interference in the electrometric measurements.

2.3.2. Oil and grease coating the pH electrode may cause sluggish response. For samples having high concentration of mineral acids, such as mine wastes and associated receiving waters, ASTM Method D-1067 may be use.

3.0 DETECTION LIMITS

3.1. **Detection Limit (DL) and Limit of Detection (LOD)**

3.1.1. DL and LOD are not applicable for this method.

3.2. **Limit of Quantitation (LOQ)**

3.2.1. Refer to EMAX-QA04 for generation, validation and verification of LOQ.

3.2.2. Established LOQ for this method is 5 mg/L.

4.0 DYNAMIC RANGE

4.1. The maximum amount of titrant used in a pre-determined amount of sample shall not exceed 50 ml. All samples analyzed above these range shall be considered estimate (over range) and shall require a smaller amount of sample or higher titrant concentration to properly quantitate.

5.0 SAMPLE HOLDING TIME & PRESERVATION

5.1. **Preservation**

5.1.1. Collected water samples are maintained at ≤ 6°C with no chemical preservation.

5.1.2. Samples should not be filtered, diluted, concentrated or altered in any way.

5.1.3. Store all samples ≤ 6°C without freezing.

5.2. **Holding Time**

5.2.1. Analyze aqueous samples as soon as possible but not to exceed 14 days from sampling date.

5.2.2. Analyze all leachates within 24 hours from extraction.

6.0 ASSOCIATED SOPs

6.1. EMAX-DM01 Data Flow and Review

6.2. EMAX-QA04 Method Detection Limit

6.3. EMAX-QA05 Training

6.4. EMAX-QA08 Corrective Action

6.5. EMAX-QC02 Analytical Standard Preparation

6.6. EMAX-QC07 Glassware Cleaning

6.7. EMAX-SM03 Waste Disposal

6.8. EMAX-SM04 Analytical and QC Sample Labeling

7.0 SAFETY

7.1. Read all MSDS for chemicals listed in this SOP.

7.2. All reagents, standards and samples shall be treated as potential hazard. Observe the standard laboratory safety procedures. Protective gear, i.e., lab coat, safety glasses, gloves, shall be worn at all times when performing this procedure. All sample and standard handling shall be performed in the fume hood.

7.3. If for any reason, solvent and/or other reagents get in contact with your skin or any other part of your body, rinse the affected body part thoroughly with copious amounts of water. If irritations persist, inform your supervisor immediately so that proper action can be taken.

8.0 INSTRUMENTS, CHEMICALS AND REAGENTS

8.1. **Instruments and Supplies**

8.1.1. pH meter: Hach One Laboratory pH/ISE Meter or equivalent

8.1.2. Autotitrator: PC Titrate

8.1.3. Combination electrode

8.1.4. Burette: 50, 25 and 10 ml

8.1.5. Beaker: 50 ml

8.1.6. Volumetric flasks: 1 L and 2 L

8.1.7. Analytical balance (capable of weighing 0.01 gm)

8.2. **Chemicals and Reagents**

8.2.1. Reagent water: Type II

9.0 STANDARDS

9.1. Purchase all standards as certified solutions as listed below (or equivalent):

STANDARD	SOURCE	CONCENTRATION
pH 4.0	VWR	NA
pH 7.0	VWR	NA
pH 10.0	VWR	NA
pH 8.0	VWR	NA
Alkalinity Std.	VWR/ERA	Certified concentration
HCl (Titrant)	VWR	0.02 N

9.2. Alternately, you may prepare alkalinity standard and HCl standard solutions as follows:

9.2.1. 0.05N Na_2CO_3

9.2.1.1. Oven dry Na_2CO_3 at 250°C for at least 4 hours and cooled in dessicator.

9.2.1.2. Accurately weigh 2.5 ± 0.2 g and dissolve it in 1 liter reagent water.

9.2.1.3. Provide 7 days expiration date for this standard.

9.2.2. Titrant (Standard Acid)

9.2.2.1. HCL stock solution; 1N: dilute 8.33 ml conc. HCl to 100 ml reagent water

9.2.2.2. HCL standard solution; 0.02 N: dilute 20 ml of 1 N HCl to 1000 ml reagent water

10.0 PROCEDURES

10.1. **Sample Preparation**

10.1.1. Aqueous Samples

10.1.1.1. Allow sample(s) to equilibrate at room temperature.

10.1.1.2. Transfer an appropriate amount of sample into a properly labeled container (see 10.4). Use reagent water for method blank and a certified standard for LCS/LCSD. Prepare a sample duplicate (SD) for every preparative batch. MS/MSD may also be included in the preparative batch depending on the project requirements.

10.1.1.3. The samples are now ready for analysis.

10.1.2. Soil/Solid Samples

10.1.2.1. Weigh 50 g of sample and add 50 ml of reagent water.

10.1.2.2. Place it in the shaker and agitate for 1 hour.

10.1.2.3. Centrifuge for 5 minutes.

10.1.2.4. Carefully, withdraw the leachate, and prepare them as described in 10.4.

10.2. **Instrument Parameters**

10.2.1. pH Meter

10.2.1.1. Electrode Channel - Channel 1

10.2.1.2. Resolution - 0.01 pH

10.2.2. Autotitrator

10.2.2.1. Electrode port - Port 1

10.3. **Calibration**

10.3.1. Manual Calibration

10.3.1.1. Transfer about 10 ml each of pH 4, 7 and 10 buffer solution into separate 20 ml vials and drop a piece of magnetic bar into each vials.

10.3.1.2. Rinse the pH meter electrode and shake off excess water.

10.3.1.3. Immerse electrode to the pH buffers and calibrate the pH meter, accordingly.

10.3.1.4. Record calibration readings in the analysis run log. Slope should be between 92- 102% to proceed to analysis.

10.3.2. Autotitration

10.3.2.1. Calibrations are performed by the autotitrator prior to sample analysis.

10.3.2.2. Transfer about 35 – 40 ml of pH 4, 7, 10 and 8 buffer solutions into separate 50 ml vials and load vials at locations 1, 2, 3 and 4 of sample tray, respectively.

10.3.2.3. After calibration is complete check if buffer solution 8 passes QC criteria of pH = 8 ± 0.05. If calibration fails to meet QC parameter, resequence and recalibrate.

10.4. **Analysis**

10.4.1. Standardization of Titrant

10.4.1.1. Titrants are purchased with certificate of analysis and concentration is verified with the analysis result of the LCS.

10.4.1.2. Perform triplicate standardization of titrant against Na_2CO_3 @ 0.05 N concentration when titrant is prepared in-house.

10.4.2. Manual Titration

10.4.2.1. **Initial pH Determination**

10.4.2.1.1. Place a clean magnetic stir bar in the sample. Position the sample container on the center of the magnetic stirrer. Switch the magnetic

stirrer power on and gradually turn the speed knob until adequate mixing is obtained.

10.4.2.1.2. Rinse the calibrated pH probe with reagent water. Shake-off the excess water into a Kim wipes paper towel. Immerse the pH meter probe into the sample. Allow the meter readout to stabilize.

10.4.2.1.3. Record the pH reading on the initial pH column. Proceed to 10.4.2.2.

10.4.2.2. **Sample Titration**

10.4.2.2.1. Fill the burette with titrant up to the mark. Position the burette to the center of the flask.

10.4.2.2.2. Titrate an appropriate amount of of sample to pH = 4.5 (± 0.04) using 0.02N HCl. Record the titrant volume under pH=4.5 column. Results for total, bicarbonate, carbonate and hydroxide alkalinity are automatically calculated by the template. Alkalinity relationships/calculations are shown in Section 10.5.

10.4.2.3. **Sample Titration for Low Alkalinity**

10.4.2.3.1. For alkalinity of < 20 mg/L, titrate 100 ml of sample using 10 ml microburette an 0.02N acid solution.

10.4.2.3.2. Stop titration at pH range 4.5 ± 0.04. Record volume and exact pH.

10.4.2.3.3. Carefully, add titrant to lower the pH to exactly 0.3 pH units and record the titrant volume.

10.4.2.3.4. Record the actual final pH at the final pH column.

10.4.3. Automatic Titraton

10.4.3.1. **Program Setup**

10.4.3.1.1. Turn-on PC and activate PC Titrator program.

10.4.3.1.2. Click on “Titrator” located at the menu bar and access “manual control”

10.4.3.1.2.1. Click on autosampler tab to load autosampler tray template and home sampler.

10.4.3.1.2.2. Next, click on the digital tab to rinse the syringe and titration cell using pumps 2, 3, and 4.

Note: Pump 2: Turns on/off syringe pump

Pump 3: Turns on/off drain

Pump 4: Turns on/off rinse pump

10.4.3.1.2.3. Check for air bubbles in the burette. If air bubbles are found, click on the serial devices tab and dispense a few ml of titrant to push the bubble out. Refill burette and repeat if necessary.

10.4.3.1.2.4. Return to the menu screen when finished.

10.4.3.1.3. From the menu screen, click on “Titrator” and access “Run titration”

10.4.3.1.3.1. Load template "Daily run no order #" and input analytical batch sequence.

Note: Remember to include a sample duplicate for every preparative batch. ICV/CCV/MS/MSD may also be included in the preparative batch depending on the project requirements.

10.4.3.1.3.2. Check sequence for accuracy and completeness. Print and retain a copy of the timetable for reference.

10.4.3.2. Sample Titration

10.4.3.2.1. Aliquot 40 ml of sample into 50 ml vials and load samples as listed on the sequence.

10.4.3.2.2. Click on the "Start" button after loading pH buffers and samples. If the sequence needs to be updated during the analysis, click "priority" on the right to pause. DO NOT CLICK STOP! Afterwards, make the required changes and click on resume to continue onto the next sample.

Note: Load 40 ml of pH buffer 7/KCl probe solution at tray location 122 before the analytical batch is complete.

10.4.3.2.3. Print the report that appears on the screen when the run is completed. Close the screen and click OK to return to the main menu.

10.4.3.2.4. Click on "Titrator" and "Examine calibrations". Print the calibration record from the previous run by choosing "port 1" on the drop-down bar. Previous calibrations can also be checked by clicking the arrows at the bottom-left of the screen.

10.5. **Calculations**

10.5.1. Calculate for Titrant Concentration (if prepared in-house)

$$N = \frac{A \, x \, B}{53.00 \, x \, C} \qquad \text{Eq.-10.5.1}$$

where:

N = Normality of titrant

A = g Na_2CO_3 dissolved in 1 L solution

B = ml Na_2CO_3 solution titrated

C = ml titrant used to inflection point

10.5.2. Phenolphtalein Alkalinity (P)

$$P = \frac{A \, x \, C \, x \, 50000}{D} \qquad \text{Eq.-10.5.2}$$

10.5.3. Total Alkalinity (T)

$$T = \frac{B \, x \, C \, x \, 50000}{D}$$ Eq.-10.5.3

where:

A = volume of titrant added to reach pH 8.3

B = volume of titrant added to reach pH 4.5 (or 4.2 for low alkalinity)

C = concentration of titrant, normality

D = volume of sample used

Alkalinity Relationships/Calculations			
Result of Titration	Hydroxide (OH) Alkalinity as $CaCO_3$	Carbonate (CO_3) Alkalinity as $CaCO_3$	Bicarbonate (HCO_3) Alkalinity as $CaCO_3$
P = 0	0	0	T
P < ½ T	0	2P	T – 2P
P = ½ T	0	2P	0
P > ½ T	2P - T	2 (T-P)	0
P = T	T	0	0

where:

P = phenolphthalein alkalinity

T = total alkalinity

10.5.4. Percent Recovery

$$R = \left(\frac{C_f - C_s}{C_o} \right) \times 100$$ Eq.-10.5.4

where:

R = percent recovery

C_f = found concentration

C_s = sample concentration (for LCS, $C_s = 0$)

C_o = known spike concentration

10.5.5. Relative Percent Difference

$$\%RPD = \frac{|C_1 - C_2|}{\left(\frac{C_1 + C_2}{2} \right)} \times 100$$ Eq.-10.5.5

where:

RPD – Relative Percent Difference

C_1 – Measured concentration of the first sample aliquot

C_2 – Measured concentration of the second sample aliquot

10.6. **Data Reduction**

10.6.1. Make a copy of the analytical run log and sample preparation log (if applicable)

10.6.2. Print a copy of the raw data and the QC report.

10.6.3. Highlight reportable results for data processing.

10.7. **Report Generation**

10.7.1. Manual Titration Report

10.7.1.1. Generate the .txt file using WDB5NT1.exe.

10.7.1.2. Generate the sample result using MSRB6T2.exe.

10.7.1.3. Generate the LCS/LCSD summary using QCICT3N1.exe.

10.7.1.4. Generate the sample duplicate result using CQITN1.exe.

10.7.1.5. Generate the case narrative using CN2.exe.

10.7.2. Automatic Titration Report

10.7.2.1. After analysis, access "Reporting" from the main menu and click on "Print or prepare shazam reports". Open report format "Water Analysis Historical Data Report.srw". Double-click on the filters and input the run # found on the front of the report printout. Export the data in an ASCII delimited text format onto the desktop by clicking on "File" and then "Export" from the menu bar. Transfer the export data onto the network via a flash drive for reporting.

10.7.2.2. Convert exported data file for reporting using ALKALN.exe.

10.7.2.3. Generate the .txt file using WDB5NT.exe.

10.7.2.4. Generate the sample result using MSRB6T.exe.

10.7.2.5. Generate the LCS/LCSD summary using QCICT3A.exe.

10.7.2.6. Generate the sample duplicate result using CQIT.exe.

10.7.2.7. Generate the case narrative using CN2.exe.

10.8. **Data Review**

10.8.1. Arrange the analysis package in sequence as detailed below. Attach all raw data to every form generated, to include re-analysis.

- Case Narrative
- Sample Results
- LCS/LCSD Summary

- Sample Duplicate Summary
- Analytical Run Log
- Raw Data
- Non-Conformance Report (If any)

10.8.2. Perform a 100% data review in accordance to EMAX-DM01 and the PSR.

10.8.3. Review the case narrative and check that it accurately describes what transpired in the analytical process. Edit as necessary to reflect essential issues not captured by the case narrative generator program.

10.8.4. Submit the analytical folder for secondary review.

10.9. **Preventive Maintenance**

10.9.1. The pH electrodes should be maintained clean and the probe returned to the probe handle after every use.

10.9.2. Instruments should receive routine preventive maintenance, which is reported in instrument-specific maintenance logs. Routine maintenance ensures that all equipment are operating under optimum condition, thus reducing the possibility of instrument malfunction that consequently affects sample results.

11.0 QUALITY CONTROL

11.1. Refer to Appendix 1 for all related Quality Control parameters, frequency, acceptance criteria and corrective action.

11.2. All labwares used in the sample preparation shall be properly treated as specified in EMAX-QC07.

11.3. All analytical standards are prepared fresh on the day of analysis. All analytical standard preparations shall follow the procedures described in EMAX-QC02 and shall be documented in the analytical standard preparation log.

11.4. Instrument parameters are checked and recorded in the instrument maintenance log prior to its use for the day.

11.5. A preparative batch shall include a MB, LCS, SD (sample duplicate) and a maximum of 20 field original samples unless otherwise specified by the project.

11.6. A valid LOQ must exist prior to sample analysis. Refer to EMAX-QA04 for details.

11.7. All analysts conducting this analysis must have an established Demonstration of Capability (DOC) as described in EMAX-QA05.

12.0 CORRECTIVE ACTION

12.1. Corrective action for each Quality Control procedure is summarized in Appendix 1.

12.2. QC Samples

12.2.1. Method Blank (MB). If MB is non-compliant consider the following suggestions to analyze and possibly correct the problem:

- Investigate the source of the problem and institute resolution to correct, minimize or eliminate the problem.
- If the analyte found in the blank is not detected in any of the field samples, consult with the Supervisor and the PM if the result can be reported otherwise, re-extract and re-analyze the method blank with the associated samples.

12.2.2. Lab Control Sample(s). If LCS is non-compliant consider the following suggestions to analyze and possibly correct the problem:

- Check for errors in calculation and concentration of the analyte solution
- If recovery of LCS is bias-high and associated sample results are non-detect, then results can be reported. If associated samples show positive results or if recovery of LCS is bias-low, then acquire or prepare a new LCS standard and titrant and re-analyze with the associated samples.
- If recovery of LCS is still non-compliant after re-analysis, check the PSR for corrective action otherwise; discuss the issue in the case narrative.

12.3. If pH electrode response is erratic and/or sluggish, record sample description on the analytical log and inform the Supervisor for further advice.

12.4. For insufficiency of sample(s), inform the Supervisor immediately for further advice.

12.5. Other anomalies encountered during the analytical process not listed in Appendix 1 shall require a non-conformance report (NCR). Refer to EMAX-QA08.

13.0 POLLUTION PREVENTION

13.1. Observe all necessary precautions to avoid spillage of sample that may go to the wastewater drains.

14.0 WASTE MANAGEMENT

14.1. Practice the "Less is Better" strategies when preparing for analytical standards. This will minimize the production of surplus chemical wastes.

14.2. Separate and properly identify all unused expired analytical standards for proper disposal.

14.3. No sample shall be dumped in the laboratory sink.

14.4. Dispose all unused samples, expired analytical standards and other wastes generated during the analytical process in accordance to EMAX-SM03.

15.0 SUPPLEMENTARY NOTES

15.1. **Definition of Terms**

15.1.1. Alkalinity of water – is its acid-neutralizing capacity. It is the sum of all titratable bases.

15.1.2. Phenolphthalein Alkalinity – is the alkalinity measured by titration to pH 8.3

1.1.1. Batch – is a group of samples that are prepared and/or analyzed at the same time using the same lot of reagents.

15.1.1.1 **Preparation Batch** - is composed of one to 20 samples of the same matrix, a method blank, a lab control sample and matrix spike/matrix spike duplicate.

15.1.2.1. **Analytical batch -** is composed of prepared samples (extracts, digestates, or concentrates), which are analyzed together as a group using an instrument in conformance to the analytical requirement. An analytical batch can include samples originating from various matrices, preparation batches, and can exceed 20 samples.

15.1.3. Limit of Quantitation (LOQ) – The minimum levels, concentrations or quantities of target variable (e.g., target analyte) that can be reported with a specified degree of confidence.

15.1.4. Material Safety Data Sheet (MSDS) – is where the physical data, toxicology and safety precaution of a certain substance is listed.

15.1.5. Calibration – is a determinant measured from a standard to obtain the correct value of an instrument output.

15.1.6. Reagent Water – is purified water free from any target analyte or any other substance that may interfere with the analytical process.

15.1.7. Method Blank – is a target-analyte-free sample subjected to the entire sample preparation and/or analytical to monitor contamination.

15.1.8. Lab Control Sample (LCS) – is a target-analyte-free sample spiked with a verified known amount of target analyte(s) or a reference material with a certified known value subjected to the entire sample preparation and/or analytical process. LCS is analyzed to monitor the accuracy of the analytical system.

15.1.9. Sample – is a specimen received in the laboratory bearing a sample label traceable to the accompanying COC. Samples collected in different containers having the same field sample ID are considered the same and therefore labeled with the same lab sample ID unless otherwise specified by the project.

15.1.10. Sample Duplicate – is a replicate of a sub-sample taken from one sample, prepared and analyzed within the same preparation batch.

15.1.11. Sub-sample – is an aliquot taken from a sample for analysis. Each sub-sample is uniquely identified by the sample preparation ID.

15.1.12. Matrix – is a component or form of a sample.

15.1.13. Re-analysis – is a repeated analysis from the same extract/leachate or sample, identified with the Lab Sample ID suffixed with “W”.

15.2. **Application of EMAX QC Procedures**

15.2.1. The procedures and QC criteria summarized in this SOP shall be applied to all projects when performing analysis for Alkalinity. In instances where there is a project or program QAPP, the requirements given in the project shall take precedence over this SOP.

15.3. **Department of Defense (DoD) Projects**

15.3.1. Samples from DoD sponsored projects shall follow the Quality Assurance Project Plan (QAPP), Statement of Work (SOW) and/or client’s quality control directive. In the absence of QAPP, the DoD Quality Systems Manual (QSM), latest update, shall be applied.

15.4. **Department of Energy Basic Ordering Agreement (DoE-BoA) Projects**

15.4.1. Samples from DoE sponsored projects shall follow the Quality Assurance Project Plan (QAPP), Statement of Work (SOW) and/or client's quality control directive. In the absence of QAPP, the DoE Quality Systems for Analytical Services (QSAS), latest update, shall be applied.

16.0 REFERENCES

16.1. Method 2320B, Standard Methods for the Examination of Water and Wastewater, 20th Edition.

16.2. Method 310.1, EPA Methods for Chemical Analysis of Water and Wastes, Editorial Rev. 1978.

16.3. 40 CFR Federal Register, Rules and Regulations Vol. 12, No.27, p. 11236, March 2007.

16.4. EMAX Quality Systems Manual, as updated.

17.0 APPENDICES

17.1. **Figures**

17.1.1.	Figure 1	Typical Raw Data
17.1.2.	Figure 1a	Typical Raw Data for Autotitration
17.1.3.	Figure 2	Typical Sample Result Summary
17.1.4.	Figure 3	Typical LCS/LCSD Summary
17.1.5.	Figure 4	Typical Sample Duplicate Result Summary
17.1.6.	Figure 5	Typical Case Narrative

17.2. **Appendices**

17.2.1.	Appendix 1	Summary of Quality Control Procedures
17.2.2.	Appendix 2	Demonstration of Capability

17.3. **Forms**

17.3.1.	310.1FA	Analytical Run Log
17.3.2.	310.1FM	Instrument Maintenance Log

Figure 1: **TYPICAL RAW DATA**

EMAX LABORATORIES, INC.

ALG003.xls

ALKALINITY RAW DATA

MISCELLANEOUS INFORMATION		
Standard	Concentration	
Acid Titrant, HCl	0.02	N
Na_2CO_3 (Zor Z_N)*	2.63	g/L
LCS	399	mg/L
MS	500	mg/L
MDL	5	mg/L
RL	5	mg/L

pH Meter Calibration			
Instrument ID:		53	
Buffer 4	4.01	07/08/11	15:10:26
Buffer 7	7	07/08/11	15:11:21
Buffer 10	10.03	07/08/11	15:12:16
pH Check Buffer (8)	7.97	07/08/11	15:13:48

$$N = \frac{(Z)(V_{Na_2CO_3})}{(53)(V_{HCl})} \qquad N = \frac{(Z_N)(V_{Na_2CO_3})}{(V_{HCl})}$$

* Standardization of Acid Titrant(N)
Z=g/L Na_2CO_3. If the concentration of Na_2CO_3 is in N, then $Z=Z_N$.

STANDARDIZATION				
$V_{Na_2CO_3}$ / V_b (ml)	V_{HCl} (ml)	DATE	TIME	Acid Titrant HCl (N)
				NA
				#DIV/0!
				#DIV/0!
				#DIV/0!
			Average HCl (N)=	0.02000

☑ Acid Titrant is purchased as certified standard solution

Book #: AAL-030
Page: 16
SOP: EMAX-310.1
Analytical Batch: **ALG003**
Analyzed By: RC

Data File Name	Lab Sample ID	Sample Amount (ml)	Sample pH	Analysis Date mm:dd:yy	Analysis Time hh:mm:ss	Volume of Acid Titant (A) ml pH=8.3	Analysis Date mm:dd:yy	Analysis Time hh:mm:ss	Volume of Acid Titant (B) ml pH=4.5	Analysis Date mm:dd:yy	Analysis Time hh:mm:ss	Vol.of Acid Titant (C) ml pH=4.2	Analysis Date mm:dd:yy	Analysis Time hh:mm:ss	Final pH	Analysis Date mm:dd:yy	Analysis Time hh:mm:ss	NOTES
ALG003-01	ALG003WB	100	5.47	07/08/11	15:16:41	NA	07/08/11	15:16:45	0.13	07/08/11	15:17:21	0.25	07/08/11	15:17:55	4.19	07/08/11	15:18:00	
ALG003-02	ALG003WL	5	9.1	07/08/11	15:19:43	1.33	07/08/11	15:22:10	2.01	07/08/11	15:23:06	NA	07/08/11	15:23:12	4.49	07/08/11	15:23:15	
ALG003-03	ALG003WC	5	9.11	07/08/11	15:26:43	1.3	07/08/11	15:28:49	2	07/08/11	15:30:26	NA	07/08/11	15:30:28	4.51	07/08/11	15:30:31	
ALG003-04	F242-01	1	6.91	07/08/11	15:31:23	NA	07/08/11	15:31:25	1.16	07/08/11	15:34:36	NA	07/08/11	15:34:38	4.49	07/08/11	15:34:39	
ALG003-05	F242-01D	1	6.81	07/08/11	15:37:53	NA	07/08/11	15:40:13	1.14	07/08/11	15:40:15	NA	07/08/11	15:40:16	4.54	07/08/11	15:40:18	
ALG003-06	F242-01M	1	8.75	07/08/11	15:45:53	0.12	07/08/11	15:47:01	1.57	07/08/11	16:02:29	NA	07/08/11	16:02:30	4.51	07/08/11	16:02:32	
ALG003-07	F242-02	1	6.77	07/08/11	16:05:44	NA	07/08/11	16:05:47	1.62	07/08/11	16:13:54	NA	07/08/11	16:13:57	4.48	07/08/11	16:13:59	
ALG003-08	F242-03	100	5.38	07/08/11	16:19:09	NA	07/08/11	16:19:14	0.12	07/08/11	16:20:49	0.25	07/08/11	16:21:32	4.24	07/08/11	16:21:34	
ALG003-09	F248-02	2	6.94	07/08/11	16:24:54	NA	07/08/11	16:24:56	1.51	07/08/11	16:29:48	NA	07/08/11	16:29:50	4.47	07/08/11	16:30:00	
ALG003-10	F248-03	1	6.59	07/08/11	16:34:44	NA	07/08/11	16:35:15	1.45	07/08/11	16:36:38	NA	07/08/11	16:36:39	4.46	07/08/11	16:36:42	
ALG003-11	F248-04	100	5.17	07/08/11	16:39:22	NA	07/08/11	16:39:23	0.1	07/08/11	16:40:10	0.21	07/08/11	16:40:59	4.22	07/08/11	16:41:02	
ALG003-12	F248-05	100	5.49	07/08/11	16:44:11	NA	07/08/11	16:44:14	0.15	07/08/11	16:46:27	0.3	07/08/11	16:46:31	4.21	07/08/11	16:46:33	
ALG003-13	F248-06	1	6.98	07/08/11	16:50:52	NA	07/08/11	16:50:54	2.19	07/08/11	16:54:30	NA	07/08/11	16:54:32	4.52	07/08/11	16:54:38	

Figure 1a: **TYPICAL RAW DATA FOR AUTOTITRATION**

Report Date: 09/01/2011 : 12:26 PM

PC-TitratION PLUS

pH and Alkalinity In-Run Report

Run Number 528 Analytical Batch# 11E5I01

Seq. #	SampleID	Data File Name	RunDate	RunTime	pH	Volume @pH 8.3	Volume @pH 4.5	Volume @pH 4.2	palk-ppm	talk-ppm	bcarb-ppm	carb-ppm	hydr-ppm	Review Notes
1	ICV PH8	11E5I01	09/01/2011	10:39 AM	7.99	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	-1.00	
2	RINSE	11E5I01	09/01/2011	10:44 AM	4.99	.00	.02	.03	.00	.56	.56	.00	.00	
3	ALI001WB	11E5I01	09/01/2011	10:48 AM	4.09	.00	.00	.00	.00	.00	.00	.00	.00	
4	ALI001WL	11E5I01	09/01/2011	11:03 AM	8.80	4.74	9.99	-1.00	189.45	399.50	20.61	378.89	.00	
5	ALI001WC	11E5I01	09/01/2011	11:11 AM	8.84	5.01	10.00	-1.00	200.34	399.89	.00	399.11	.78	
6	H838-01	11E5I01	09/01/2011	11:20 AM	7.51	.00	5.00	-1.00	.00	199.82	199.82	.00	.00	
7	H838-01D	11E5I01	09/01/2011	11:27 AM	7.60	.00	4.92	-1.00	.00	196.89	196.89	.00	.00	
8	H838-02	11E5I01	09/01/2011	11:34 AM	7.67	.00	4.89	-1.00	.00	195.80	195.80	.00	.00	
9	H838-03	11E5I01	09/01/2011	11:41 AM	7.74	.00	5.00	-1.00	.00	199.94	199.94	.00	.00	
10	H838-04	11E5I01	09/01/2011	11:48 AM	7.73	.00	5.01	-1.00	.00	200.24	200.24	.00	.00	
11	H838-05	11E5I01	09/01/2011	11:57 AM	7.76	.00	5.02	-1.00	.00	200.71	200.71	.00	.00	
12	H838-06	11E5I01	09/01/2011	12:04 PM	7.79	.00	4.98	-1.00	.00	199.07	199.07	.00	.00	
13	H838-07	11E5I01	09/01/2011	12:11 PM	7.77	.00	5.10	-1.00	.00	203.92	203.92	.00	.00	
14	H838-08	11E5I01	09/01/2011	12:18 PM	7.78	.00	5.10	-1.00	.00	204.16	204.16	.00	.00	
15	RINSE	11E5I01	09/01/2011	12:24 PM	5.61	.00	.04	.09	.00	-.34	-.34	.00	.00	

Analyzed by: Rc Reviewed by: Rc Date: 9/1/11

Page: 1 of 1
PC-TitratION PLUS by Man-Tech Associates, Inc.

pH AND ALKALINITY IN-RUN REPORT.SRW
Copyright Hinterland Software Ltd.

Figure 2: TYPICAL SAMPLE RESULT SUMMARY

METHOD 310.1
ALKALINITY

Client : XYZ, INC.
Project : CLEAN WATER PROJECT
Batch No. : 11F242

Matrix : WATER
Instrument ID : 53

SAMPLE ID	EMAX SAMPLE ID	RESULTS (mg/L)	DLF	MOIST	RL (mg/L)	MDL (mg/L)	Analysis DATETIME	Extraction DATETIME	LFID	CAL REF	PREP BATCH	Collection DATETIME	Received DATETIME
MBLK1W	ALG003WB	ND	1	NA	5.00	5.00	07/08/1115:18	NA	ALG003-01	NA	ALG003W	NA	NA
LCS1W	ALG003WL	402	1	NA	5.00	5.00	07/08/1115:23	NA	ALG003-02	NA	ALG003W	NA	NA
LCD1W	ALG003WC	400	1	NA	5.00	5.00	07/08/1115:30	NA	ALG003-03	NA	ALG003W	NA	NA
25GW114-0611	F242-01	1160	1	NA	5.00	5.00	07/08/1115:34	NA	ALG003-04	NA	ALG003W	06/28/1112:33	06/29/11
25GW114-0611DUP	F242-01D	1140	1	NA	5.00	5.00	07/08/1115:40	NA	ALG003-05	NA	ALG003W	06/28/1112:33	06/29/11
25GW121-0611	F242-02	1620	1	NA	5.00	5.00	07/08/1116:13	NA	ALG003-07	NA	ALG003W	06/28/1110:33	06/29/11
25GW129-0611	F242-03	ND	1	NA	5.00	5.00	07/08/1116:21	NA	ALG003-08	NA	ALG003W	06/28/1114:40	06/29/11

Figure 3: TYPICAL LCS/LCSD SUMMARY

EMAX QUALITY CONTROL DATA
LCS/LCD ANALYSIS

CLIENT: XYZ, INC.
PROJECT: CLEAN WATER PROJECT
BATCH NO.: 11F242
METHOD: METHOD 310.1

MATRIX:	WATER			% MOISTURE:	NA
DILUTION FACTOR:	1	1	1		
SAMPLE ID:	MBLK1W				
LAB SAMP ID:	ALG003WB	ALG003WL	ALG003WC		
LAB FILE ID:	ALG003-01	ALG003-02	ALG003-03		
DATE EXTRACTED:	NA	NA	NA	DATE COLLECTED:	NA
DATE ANALYZED:	07/08/1115:18	07/08/1115:23	07/08/1115:30	DATE RECEIVED:	NA
PREP. BATCH:	ALG003W	ALG003W	ALG003W		
CALIB. REF:	NA	NA	NA		

ACCESSION:

PARAMETER	BLNK RSLT (mg/L)	SPIKE AMT (mg/L)	BS RSLT (mg/L)	BS % REC	SPIKE AMT (mg/L)	BSD RSLT (mg/L)	BSD % REC	RPD (%)	QC LIMIT (%)	MAX RPD (%)
Alkalinity	ND	399	402	101	399	400	100	0	80-120	20

Figure 4: **TYPICAL SAMPLE DUPLICATE SUMMARY**

EMAX QUALITY CONTROL DATA
DUPLICATE SAMPLE ANALYSIS

CLIENT: XYZ, INC.
PROJECT: CLEAN WATER PROJECT
BATCH NO.: 11F242
METHOD: METHOD 310.1

MATRIX:	WATER		% MOISTURE:	NA
DILUTION FACTOR:	1	1		
SAMPLE ID:	25GW114-0611			
EMAX SAMP ID:	F242-01	F242-01D		
LAB FILE ID:	ALG003-04	ALG003-05		
DATE EXTRACTED:	NA	NA	DATE COLLECTED:	06/28/11 12:33
DATE ANALYZED:	07/08/1115:34	07/08/1115:40	DATE RECEIVED:	06/29/11
PREP. BATCH:	ALG003W	ALG003W		
CALIB. REF:	NA	NA		

ACCESSION:

PARAMETER	SMPL RSLT (mg/L)	DUPL RSLT (mg/L)	RPD RSLT %	QC LIMIT (%)
Alkalinity	1160	1140	2	20

Figure 5: **TYPICAL CASE NARRATIVE**

CASE NARRATIVE

Client : XYZ, INC.

Project : CLEAN WATER PROJECT

SDG : 11F242

METHOD 310.1
ALKALINITY

A total of three (3) water samples were received on 06/29/11 for Alkalinity analysis, Method 310.1 in accordance with Methods for the Chemical Analysis of Water and Wastes (MCAWW) (EPA/600/4-79/020).

Holding Time
Samples were analyzed within the prescribed holding time.

Calibration
Calibration was performed as prescribed by the method. All calibration requirements were within acceptance criteria.

Method Blank
Method blank was analyzed at the frequency required by the project. For this SDG, one method blank was analyzed with the samples. Result was compliant to project requirement.

Lab Control Sample
A set of LCS/LCD was analyzed with the samples in this SDG.
Percent recoveries for ALG003WL/C were all within QC limits.

Matrix QC Sample
Matrix QC sample was analyzed at the frequency prescribed by the project.
Percent recovery for F242-01M was within project QC limits.
Sample duplicate was also analyzed with the samples. RPD was within project limit.

Sample Analysis
Samples were analyzed according to prescribed analytical procedures. All project requirements were met otherwise anomalies were discussed within the associated QC parameter.

Appendix 1: SUMMARY OF QUALITY CONTROL PROCEDURES

QC PROCEDURE	FREQUENCY	ACCEPTANCE CRITERIA	CORRECTIVE ACTION	1st Rvw	2nd Rvw
Instrument Calibration	Daily prior to sample analysis	± 0.05 pH units	Correct the problem and re-calibrate prior to sample analysis		
Method Blank	One method blank per preparation batch	Result ≤ LOQ	If sample results are non-detect, no corrective action is needed, otherwise correct the problem and re-analyze all associated samples.		
LCS	One LCS per preparation batch	% Recovery: 80 – 120%	Correct the problem and re-analyze all associated samples.		
Sample Duplicate	One sample duplicate per preparation batch	RPD ≤ 20%	Discuss in the case narrative		
Comments: Refer to PSR for flagging criteria.			Reviewed By:		
			Date:		

Appendix 2: DEMONSTRATION OF CAPABILITY

DEMONSTRATION OF CAPABILITY
METHOD EPA 310.1

Unit: mg/L
Sample Amount(ml): 25

Analyzed By: R. Cheung
Date Analyzed: 09/02/11
09/09/11

PARAMETER	E5I02004 ALI002WL	E5I02005 ALI002WC	E5I03004 ALI003WL	E5I03005 ALI003WC	True Value (mg/L)	Ave Conc.	Ave % Rec.	SD	RPD	QC Criteria	Comments
Alkalinity	394	394	402	401	399	398	100	4.349	1.09	80 - 120	Passed

310.1FA: ANALYTICAL RUN LOG

EMAX LABORATORIES, INC.

ANALYSIS RUN LOG
for
ALKALINITY

Page 1

Note: For samples and relevent QCs/Standards analyzed, refer to attached analytical sequence.

☐ Titration end point: pH 4.5 ± 0.04

☐ Low alkalinity: pH 4.2 ± 0.04

MS/MSD amount of spike:

Comments:

Book#: AAL-031

Instrument No.: ☐ 53 ☐ 97 ☐ E5

Analytical Batch:

Analytical Sequence:

SOP #	Rev. #
☐ EMAX-310.1	
☐ EMAX-2320B	
☐ EMAX-	

STANDARDS ID	CONC. (mg/L)
0.02N HCL	
LCS	
MS/MSD	
ICV	

pH Buffer	ID
pH 4	
pH 7	
pH 10	
pH 8.0 (Check)	

Analyzed By:

Date:

310.1FM: INSTRUMENT MAINTENANCE LOG

EMAX LABORATORIES, INC.

Page 1

INSTRUMENT MAINTENANCE LOG

Instrument No: E5 Month: Year: 201_ Book # ME5-002

Date							
Titrant Bottle Level							
DI Bottle Level							
Waste Bottle Level							
Titration Module							
Buret Module							
pH Probe							
Printer Paper							
Autosampler							
Analyst Initials							
Trouble Shooting							
Problem(s) Encountered							
Corrective Action							
Return To Specs (Analyst Initials)							

Code	Problems Encountered	Code	Corrective Action

STANDARD OPERATING PROCEDURES

PERCHLORATE BY ION CHROMATOGRAPHY ANALYSIS

SOP No.:	EMAX-314.0	Revision No.	4	Effective Date:	15-Dec-11
Prepared By:	Lucita Arzadon			Date:	12-14-11
Approved By:	Kenette Pimentel QA Manager			Date:	12·14·11
Approved By:	Caspar Pang Laboratory Director			Date:	12-14-11

Control Number: 314.0-04-

1.0 SCOPE AND APPLICATION

1.1. This method is applicable for the determination of perchlorate in drinking water, surface water, mixed domestic and industrial wastewaters, ground waters, reagent waters and solids (extracted by leaching) by Ion Chromatography.

1.2. This SOP is an adaptation of US EPA Method 314.0.

2.0 SUMMARY OF METHOD

2.1. A small amount of sample (1 mL) is injected into an ion chromatograph. The sample is passed through a guard column, anion exchange column, suppressor device and the anions are detected by a conductivity detector.

2.2. **Interferences**

2.2.1. Direct Chromatographic Coelution – occurs when a non-target analyte elutes very close to the retention time of target analytes. This interference may be solved by changing the column, eluent strength, modifying the eluent with organic solvents (if compatible with IC columns), changing the detection systems or selective removal of the interference.

2.2.2. Concentration-Dependant Coelution – occurs when the response of the neighboring peak overlaps into the retention time window of the target anion. Sample dilution or eluent dilution may resolve this interference.

2.2.3. Ionic Character Displacement – occurs when the retention times significantly shift due to the influence of high ionic strength matrices (high mineral content or hardness) overloading the exchange sites in the column and significantly shortening the target analytes' retention times. Sample dilution or eluent dilution may resolve this interference.

2.2.4. Pretreatment Cartridges – can be an effective eliminator of matrix interference however artifacts are known to leach from certain cartridges. If samples are passed through pretreatment cartridge, all instrument calibration standards must be treated the same.

2.2.5. Method Interferences – may be caused by reagents, glassware and other substances that the sample may come into contact during the analytical process. It is imperative that reagent water production is monitored. Only reagent grade or better are used. Eluate must be passed through 0.2 µm filter. Columns must be sufficiently flushed.

2.2.6. High concentrations of common anions – Common anions such as chloride, sulfate and carbonate can make the analysis problematic by destabilizing the baseline in the retention time window for perchlorate. These common anion levels can be indirectly assessed by monitoring the conductivity prior to analysis. Sample dilution and/or pre-treatment must be performed.

2.2.7. Carry Over Peaks – may be caused by a preceding sample with high concentration or a late eluting compound. Ozonated and chlorine dioxide matrices were observed to have unknown analytes that elute at approximately 23 minutes. Extending the runtime to 25 minutes to allow elution of any interfering peaks may eliminate potential carry over of late eluting peaks.

3.0 DETECTION LIMITS

3.1. Detection Limit (DL), Limit of Detection and Limit of Quantitation

3.1.1. Refer to EMAX-QA04 for generation, validation and verification of DL, LOD and LOQ. ***Please note that the seven replicate analyses must be processed through the entire analytical method over a three day period.***

3.1.2. Established limits are as follows:

MATRIX	DL	LOD	LOQ
Water (µg/L)	0.68	1	2
Soil (µg/Kg)	7.60	10	20

4.0 DYNAMIC RANGE

4.1. The highest quantifiable range requiring no dilution is equal to the concentration of the highest calibration point (see Section 9.3.1). All samples analyzed above this range shall be considered "over-range" and shall require dilution in order to be properly quantified.

4.2. The lowest quantifiable range of diluted samples is equal to the concentration of the lowest calibration point. All diluted samples analyzed below this range shall be considered as "under-range" and shall require lower dilution factor in order to be properly quantified.

5.0 SAMPLE HOLDING TIME AND PRESERVATION

5.1. Holding Time

5.1.1. Analyze all samples within 28 days from sample collection.

5.2. Preservation

5.2.1. Aqueous samples shall be collected in either HDPE or glass bottles and shall have no chemical preservatives. Samples shall be stored at a temperature similar to how they are received to protect the samples from temperature extremes.

5.2.2. Soil samples are collected in glass jars or brass tubes. Samples shall be stored at a temperature similar to how they are received to protect the samples from temperature extremes. The extracts shall be treated as water samples.

5.2.3. Store the samples at ≤ 6°C without freezing.

6.0 ASSOCIATED SOPs

6.1. EMAX-DM01 Data Flow and Review

6.2. EMAX-QA04 Detection Limit

6.3. EMAX-QA05 Training

6.4. EMAX-QA08 Corrective Action

6.5. EMAX-QC02 Analytical Standard Preparation

6.6. EMAX-QC07 Glassware Cleaning

6.7. EMAX-SM03 Waste Disposal

6.8. EMAX-SM04 Analytical and QC Sample Labeling

7.0 SAFETY

7.1. Read all MSDS for chemicals listed in this SOP.

7.2. The toxicity or carcinogenicity of each reagent used in this method has not been fully established. Each chemical should be regarded as a potential health hazard and exposure should be as low as reasonably achievable. Cautions are specifically listed below in Section 7.3 for hazardous materials.

7.3. Sodium Hydroxide (NaOH), used in the preparation of the eluent is considered caustic and have the potential to be highly toxic or hazardous; consult MSDS.

7.4. Treat all reagents, standards and samples as potential hazards. Observe the standard laboratory safety procedures. Wear protective gear, i.e. lab coat, safety glasses, gloves, at all times when performing this procedure.

7.5. If for any reason, solvent and/or other reagents get in contact with your skin or any other part of your body, rinse the affected body part thoroughly with copious amounts of tap water. If irritations persist, inform your supervisor immediately so proper action can be taken.

8.0 INSTRUMENTS, CHEMICALS AND REAGENTS

8.1. **Instruments and Supplies**

IC	Dionex Ion Chromatography or equivalent
Guard Column	AG16
Column	AS16
Suppressor Device	ASRS 300 4mm
Detector	Conductivity Cell
Autosampler	766 IC Sample Processor (Metrohm)
Data Acquisition	EZ Chrom 6.8V
Conductivity Meter	1-10,000 µS/cm
Balance	Toploading, sensitive to ± 0.0001 gm
Autosampler vials	10 ml
Filters	0.2 µm & 0.45 µm PTFE Membrane or equivalent

Matrix Pretreatment Cartridge	Barium form- OnGuard Ba cartridge 046072 or equivalent Silver form – OnGuard Ag cartridge 039637 or equivalent Hydrogen form – OnGuard H cartridge 039596 or equivalent
Volumetric Flasks	100, 250, 1000 ml, 2000 ml
Sample Containers	Plastic snap seal containers 50 ml & 125 ml
Micropipettes	100 & 1000 µl; 1,2,5,10 & 20 ml
Syringe	5mL Luer-lock disposable
Filter	0.45 µm membrane
Gas	Nitrogen, high purity grade

8.2. **Chemicals and Reagents**

Reagent water	De-ionized water (ASTM Type II) or equivalent
Conductivity Calibration Standards	10 µS/cm and 100000 µS/cm
Eluent solution	34.62 mM NaOH: Add 5.54 g of 50% w/w NaOH to a 2 L volumetric flask and dilute to the mark with reagent water or commercially reagent grade solution may be used. This solution must be purged with Nitrogen for at least 60 minutes prior to use.

9.0 STANDARDS

9.1. **Standard Preparation**

9.1.1. Refer to EMAX-QC02 for proper preparation of analytical standards

9.2. **Stock Standards Solution (SSS)**

9.2.1. A primary stock standard of Perchlorate (ClO_4) is prepared from a neat Sodium Perchlorate standard from which a 1000 mg/L is prepared by dissolving 1.2312g $NaClO_4$ in reagent water and dilute to 1 L. It is used to prepare all calibration standards, LFB and LFM. Alternately, this primary stock standard may be purchased commercially at 1000 mg/L as a certified solution.

9.2.2. A secondary source stock standard at 1000 mg/L is purchased commercially as a certified solution from a different source.

9.2.3. Intermediate Standard

9.2.3.1. Perchlorate intermediate standard, 1.0 mg/L. Dilute 100 µL of stock solution to 100 mL with reagent water.

9.3. **Calibration Standards (CAL)**

9.3.1. Initial Calibration Standard

9.3.1.1. The initial calibration consists of five standards and reagent pure water blank. Using a micropipette, add the standard solutions as prescribed in the table below

into a 100 mL volumetric flask containing approximately 50 mL of S0. Dilute to mark using S0.

CAL Standards	Intermediate Standard Volume (ml)	Final Concentration (µg/L)
S0	0	0
S1	0.2	2
S2	0.4	4
S3	1.0	10
S4	2.5	25
S5	3.0	30

9.3.2. Quality Control Sample (QCS/ICV)

9.3.2.1. Using the secondary source stock standard, prepare intermediate standard as described in 9.2.3. Prepare QCS at 25 µg/L by diluting 2.5 mL of intermediate standard to 100 mL of reagent water.

9.3.2.2. Use QCS to initially verify initial calibration.

9.3.3. Daily Calibration Standards

9.3.3.1. **Initial Calibration Check (ICCS)** – Prepare a standard for MRL as S1. Use this standard to verify the previously established reporting limit from the initial calibration.

9.3.3.2. **Continuing Calibration Checks (CCCS) and End Calibration Checks (ECCS)** – Prepare a standard for continuing calibration checks at 15 µg/L and S5. These standards are analyzed alternately as calibration checks bracketing every 10 field samples.

9.4. **Stock Spiking Solution (LFB & LFM)**

9.4.1. Using the primary stock standard or equivalent, dilute 1 mL to 50 mL solution to yield a concentration of 20 mg/L.

9.4.2. Use this standard to fortify LFB and LFM.

9.5. **Instrument Performance Check Solution (IPC)**

9.5.1. Prepare IPC standard at the S4 level from the secondary stock standard in mixed common anion stock solution at the MCT (See Section 10.3.4). Use this standard to verify matrix conductivity threshold.

9.6. **Conductivity Meter Calibration Solution (CMC)**

9.6.1. Purchase a certified Potassium Chloride (KCl) solution at 745 mg/L. This solution should read 1410 µS/cm at 25°C on a properly functioning conductivity meter.

9.6.2. Alternately, prepare by dissolving 0.745 g of KCl in reagent water and dilute to a final volume of 1 L.

9.7. **Mixed Common Anion Stock Solution (MA)**

9.7.1. Purchase a certified solution of Sodium Chloride (NaCl), Sodium Sulfate (Na_2SO_4), and Sodium Carbonate (Na_2CO_3) each one at 25,000 ppm.

9.7.2. Alternately, prepare solutions by dissolving the following salts in reagent water to a final volume of 100 mL.

Sodium Chloride (NaCl)	4.0 g
Sodium Sulfate (Na_2SO_4)	3.72 g
Sodium Carbonate (Na_2CO_3)	4.4 g

10.0 PROCEDURES

10.1. Sample Preparation

10.1.1. Soil Sample

10.1.1.1. Allow all samples to equilibrate to room temperature.

10.1.1.2. Open the container and discard the top half-inch layer. Mix the sample thoroughly and discard any foreign objects, e.g., any vegetation, sticks, and rocks.

10.1.1.3. Weigh 10 grams from each sample to a properly labeled sample container and record the weight to the nearest 0.1 g.

10.1.1.4. Measure 100 mL of reagent water and add to each sample. Add 100 mL of reagent water to a sample container for LRB and LFB. Place the bottles in a shaker and agitate the mixture for 10 minutes.

10.1.1.5. Centrifuge the samples for 15-30 minutes or allow the particles to settle.

10.1.1.6. Treat the aqueous phase like a water sample. Proceed to Section 10.1.2.

10.1.2. Aqueous Sample – Matrix Conductance Verification

10.1.2.1. Allow the samples to equilibrate with room temperature.

10.1.2.2. Using a Luer-lock disposable syringe, withdraw 20 ml of sample. Filter each sample through a 0.45 µm membrane filter.

10.1.2.3. Check the conductivity of each sample with a calibrated conductivity meter (Section 10.3.1). Refer to Section 10.3.4 for establishing MCT.

- If the conductivity reading is < MCT, proceed to Section 10.1.4.
- If the conductivity reading is ≥ MCT, proceed to Matrix Pretreatment Section 10.1.3.

Note: If a sample is subjected to matrix pretreatment, the LRB and LFB must pass through the same process.

10.1.3. Matrix Pretreatment

10.1.3.1. Rinse individual pretreatment cartridges with reagent water.

10.1.3.2. Stack the rinse cartridges in series OnGuard Ba → OnGuard Ag →OnGuard H.

10.1.3.3. Using a Luer lock plastic syringe, withdraw about 5 mL of sample, attached to the stack of cartridges.

10.1.3.4. Collect about 10-20 mL sample and check the conductivity.

10.1.3.5. If the conductivity reading is < MCT, collect the remaining filtrate and proceed to Section 10.1.4.

10.1.3.6. If the conductivity reading is ≥ MCT, dilute the sample by a factor that will bring the conductivity reading to < MCT. (For example, using data given in Figure 5 where MCT is at 5657.887, a sample with conductivity reading of 8000 must be diluted 2x to achieve a conductivity reading of <MCT). Proceed to Section 10.1.4.

10.1.4. Prepare For Analytical Batch

10.1.4.1. Take clean sample vials equal to the number of samples to be analyzed not to exceed 20 field samples. If number of samples is ≤ 10 add vials for IPC, LRB, LFB, LFM, Sample Duplicate and ECC. If samples > 10 add three more vials for CCC, LFM and Sample Duplicate.

10.1.4.2. Spike 100 µL of LFM standard to the LFB and LFM designated vials.

10.1.4.3. Using a calibrated micropipette, add 10 mL of reagent water for LFB, and the designated matrix spike sample for LFM. Seal the vials and shake to attain homogeneity on the mixture.

10.1.4.4. Fill the sample vials with about 10 mL of the respective samples.

10.2. **Instrument Parameters**

10.2.1. Instrument Set Up

Instrument	DX-500
Detector	Conductivity
Sample Flow Rate	1.5 mL/min
Isocratic Pump Pressure	1700 – 2000 psi
Sample Loop	1 mL
Eluent Pressure	Optimize within 4 – 5 psi
Regenerant Pressure	Optimize within 15 – 16 psi
Run Time	18 min
Scale Setting (µS)	0.5

10.2.2. Start the flow of the regenerant by pressurizing a regenerant reservoir with nitrogen to ensure constant delivery to the column. Prime the pump to eliminate air bubbles in the system and equilibrate the column for 30 minutes or until stable baseline is obtained.

10.3. **Calibration**

10.3.1. Conductivity Meter Calibration

10.3.1.1. Set the conductivity meter to ON.

10.3.1.2. Verify cell constant by pressing [K] key. The display should read “K=1.000S/cm”.

10.3.1.3. Prepare 20mL each of conductivity calibration standards (10 µS/cm and 100000 µS/cm) in standard vessels. Prepare also 20 mL standard CMC solution (See Section 9.6.1) in another standard vessel.

10.3.1.4. Erase previous calibration data as described below.

10.3.1.4.1. Press the [CHECK] KEY, "CHK" will appear on the right corner of the display.

10.3.1.4.2. Press and hold the [ENTER] key for 10 seconds, "0" zero will be displayed at the far left of the screen to indicate that all calibration data has been cleared.

10.3.1.4.3. Release the [ENTER] key to return to the measurement mode.

10.3.1.5. Thoroughly rinse the conductivity electrode with reagent water.

10.3.1.6. Place the first calibration standard on the magnetic stirrer. Immerse the electrode.

10.3.1.7. Press the [MODE] key until Conductivity (µS/cm) reads on the display. Adjust the value on the display to the known value of the standard. "CAL" will flash on the display. Press and hold the arrow key to advance the adjustment faster.

10.3.1.8. With the correct value on the display, press the [ENTER] key to accept the value to the calibration point.

10.3.1.9. Repeat steps 10.3.1.6 to 10.3.1.8 with the second calibration standard.

10.3.1.10. Review the calibration data after the unit has been calibrated. Press the [CHECK] key once, "CHK" will appear on the display and in alternating "billboard" readout, the display will first show the calibration number and then the expected value.

Example of readout:

1 (first calibration)

10 µS (expected value per cm)

2 (second calibration)

100000 µS (expected value per cm)

10.3.1.11. Press the [MODE] key to return to measurement mode.

10.3.1.12. Place the standard CMC solution vessel on the magnetic stirrer and place the electrode in the solution.

10.3.1.13. The reference conductance of this solution is 1410 µS/cm at 25°C. The conductivity meter must yield a conductance between 1380 µS/cm and 1440 µS/cm. Record the reading in the analysis log.

10.3.1.14. If the display reading is not within the acceptable range, repeat the calibration starting in Section 10.3.1.4.

10.3.2. Initial Calibration (ICAL)

10.3.2.1. Set up the instrument with the proper operating parameters established in Section 10.2.

10.3.2.2. Using the data acquisition program, EZChrom, click File menu and pick New Method on the pull-down menu. The sequence table will be initiated and the display looks similar to the table below.

Run	Sample ID	Method	Filename
1	Instrument Blank	IC57F24.met	JF24.001
2	S0	IC57F24.met	JF24.002
3	S1	IC57F24.met	JF24.003
4	S2	IC57F24.met	JF24.004
5	S3	IC57F24.met	JF24.005
6	S4	IC57F24.met	JF24.006
7	S5	IC57F24.met	JF24.007
8	ICV	IC57F24.met	JF24.008
9	ICB	IC57F24.met	JF24.009

Note: *For Method and Filename convention, refer to EMAX-SM04.*

Under the Method column, the convention AAIIMDD is followed, defined as:

AA – analytical code (e.g., IC)

II – instrument code (e.g., 57)

MDD – calibration month and day (e.g., F24 for June 24)

Under the Filename column, the convention IMDD.XXX is followed, defined as:

I – data identifier assigned to the specific instrument (e.g., J for Inst.57)

MDD –analytical run date (e.g., F24 for June 24)

XXX – sequential number that resets to 001 at the beginning of each analytical batch.

10.3.2.3. Set the calibration standards on the Peak Table as shown below:

Analyte	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Perchlorate Conc.	0	2	4	10	25	30

10.3.2.4. Place the standards in order into the autosampler rack starting from S0.

10.3.2.5. Click on [Batch Run] icon to initiate analysis of the standards. A printout is generated every after a standard is completed.

10.3.2.6. After all the standards are analyzed, the data acquisition software automatically plots the calibration curve of peak area against concentration, and calculates the coefficient of determination (r^2). Press the [Recalib] icon to check the calibration curve and the r^2.

10.3.2.7. Check Appendix 1 for acceptance criteria and corrective action.

10.3.3. Establish Retention Time Window

10.3.3.1. Calculate the average retention time of perchlorate from the ICAL points.

10.3.3.2. The retention time window is ± 5% of the average RT.

10.3.4. Matrix Conductivity Threshold (MCT)

10.3.4.1. Initially establish the MCT by the following procedure. Using the Perchlorate intermediate standard and MA standard, prepare the following standards.

MCT Level	Perchlorate (1 mg/L) Aliquot, mL	MA Solution (2,500 mg/L) Aliquot, mL	Final Volume in reagent water (mL)
MCT0	2.5	0	100
MCT1	2.5	0.2	100
MCT2	2.5	0.4	100
MCT3	2.5	0.8	100
MCT4	2.5	1.2	100
MCT5	2.5	1.6	100
MCT6	2.5	2.4	100
MCT7	2.5	3.2	100
MCT8	2.5	4.0	100

10.3.4.2. Using the calibrated conductivity meter, measure and record the conductivity of each solution.

10.3.4.3. Analyze each solution for perchlorate. Tabulate the peak area to peak height ratio (A/H) and the concentration of perchlorate.

10.3.4.4. Calculate the A/H ratio percent difference ($PD_{A/H}$) using Eq. 10.5.1.

10.3.4.5. Plot the conductivity versus the $PD_{A/H}$. The resulting regression analysis should yield an r^2 >0.95. Calculate the MCT (conductivity at 20% $PD_{A/H}$).

10.3.4.6. Plot the concentration of MA versus conductivity. Using the equation of the line, calculate the concentration of the MA to obtain the determined MCT at 20% $PD_{A/H}$.

10.3.4.7. Refer to Figure 5 for a Typical Matrix Conductivity Threshold Regression Analysis.

10.3.4.8. As an alternate to the regression analysis, establish the MCT at the conductance level of the highest MA level which yielded a $PD_{A/H}$ value below the 20% threshold.

10.4. **Analysis**

10.4.1. Analytical Sequence

10.4.1.1. IPC – instrument performance check standard at MCT

10.4.1.2. LRB – lab reagent blank

10.4.1.3. ICC – initial calibration check standard at the MRL (S1)

10.4.1.4. LFB – lab fortified blank

10.4.1.5. LFM – lab fortified matrix sample

10.4.1.6. Samples – maximum of 10 field samples. When a sample(s) required BA/AG/H pretreatment, insert a pretreated LRB and pretreated LFB.

10.4.1.7. Sample Duplicate – use the same sample used for LFM

10.4.1.8. CCC – continuing calibration check standard at 15 µg/L

10.4.1.9. Samples – maximum of 10 field samples. Similarly, when a sample(s) required BA/AG/H pretreatment, insert a pretreated LRB and pretreated LFB.

10.4.1.10. ECC – ending calibration check standard at high level (S5)

10.4.2. Sample Result Evaluation

10.4.2.1. Evaluate QC parameters as soon as available.

10.4.2.2. Every 10 field samples should be bracketed with CCC. Alternately analyze at 15 µg/L level and S5 level after every 10 samples.

10.4.2.3. For samples that fail MCT and have been pretreated, fortify with perchlorate at a concentration greater than the level determined in the native sample prior to pretreatment. Pre-treat the sample then analyze to assess perchlorate recovery from that matrix.

10.4.2.4. If the sample concentration exceeds the initial calibration range, perform appropriate dilution to bring the concentration to be within the range and reanalyze the dilution. Bracket all re-analyses due to dilution with continuing calibrations.

10.4.2.5. Check each of the instrument performance checks that it meets the acceptance criteria set forth in Appendix 1.

10.4.2.6. Check the Retention Time (RT) of perchlorate.

10.4.2.6.1. RT should not vary more than 5% from the average of initial calibration.

10.4.2.7. Check the peaks for all positive results. Refer to Figure 1 for typical peak evaluation.

- The same peak integration technique applied in the initial calibration must be applied during the analysis of field samples.
- Peaks must be sharp and properly integrated.
- When manual integration is necessary, follow the procedures described in EMAX-DM01 Section 4.4.3.
- If a peak appears to be cryptic/anomalous, consult the supervisor.

10.4.2.8. Rule-out any suspicion of carry-over. Any sample with trace amount of analyte(s) seen in a previous sample that exceeds the calibration range needs to be re-analyzed.

10.4.2.9. Check the LRB for absence of contamination.

10.4.2.10. Check the LFB for method performance.

10.4.2.11. Check the LFM for absence or presence of matrix interference.

10.5. **Calculations**

10.5.1. Calculate A/H ratio percent difference ($PD_{A/H}$)

$$PD_{A/H} = \frac{|A/H_{LFB} - A/H_{IPCS}|}{A/H_{LFB}} \qquad \text{Eq.-10.5.1}$$

where:

$PD_{A/H}$ – A/H ration percent difference

A/H_{LFB} – A/H ratio of LFB

A/H_{IPCS} – A/H ratio of IPCS

10.5.2. Calculation for water samples, if the initial sample taken was V_i and diluted to V_f ml, then calculate the concentration using the following equation:

$$Cw = (C)(DF) \qquad \text{Eq.-10.5.2}$$

where:

C_w – Concentration in original sample, in µg/L

C – Computer generated concentration in diluted sample in µg/L

DF – Dilution factor = V_f/V_i

V_i – Initial volume of the sample, in mL

V_f – Final volume of diluted sample, in mL

10.5.3. Calculation for solid samples

$$Cs = C \times \frac{Ve}{Ws} \times DF \times \frac{100}{100 - \%M} \qquad \text{Eq.-10.5.3}$$

where:

C_s – Concentration of the sample based on dry weight in µg/Kg

C – Computer generated concentration in diluted digestate in µg/L

V_e – Volume of extract, mL

W_s – Weight of "wet sample" in g

DF – Dilution factor of extract; DF = V_f/V_i

V_i – Initial volume of the sample extract, in mL

V_f – Final volume of diluted sample extract, in mL

$\%M$ – Percent Moisture of "wet sample"

If the dilution factor and ratio of extract volume/sample weight are entered in the sequence run table file, the concentration is represented in wet weight.

10.5.4. Accuracy and Precision

10.5.4.1. Calculate for Percent Recovery

$$\% R = \frac{\left(C_f - C_s\right)}{C_o} \; x \; 100 \qquad \text{Eq.-10.5.4.1}$$

where:

$\%R$ – Is the percent recovery

C_f – Is the concentration found

C_s – Is the concentration of the sample (for LFB, $C_o = 0$)

C_o – Is the known concentration of spiked solution

10.5.4.2. Calculate for Relative Percent Difference

$$RPD = \frac{\left|C_1 - C_2\right|}{\left(\frac{C_1 + C_2}{2}\right)} \times 100 \qquad \text{Eq.-10.5.4.2}$$

where:

RPD – Relative Percent Difference

C_1 – Measured concentration of the first sample aliquot

C_2 – Measured concentration of the second sample aliquot

10.6. **Data Reduction**

10.6.1. Make a copy of the analytical run log and sample preparation log.

10.6.2. Print a copy of the raw data and the QC report.

10.6.3. Highlight the data to be reported.

10.6.4. Collate the reportable data separating the QC results from the sample results.

10.6.5. Keep all other data generated with the analytical folder marked with “For record only”.

10.7. **Report Generation**

10.7.1. Generate the method.txt file using WDBX[1].exe.

10.7.2. Generate the sample results using MSRBX[1].exe

10.7.3. Generate the LCS and MS summary using QCIC.exe.

10.7.4. Generate the sample duplicate result using CQ1N.exe.

10.7.5. Generate the case narrative using CN2.exe.

10.8. **Data Review**

[1] X – version number of the program

10.8.1. Arrange the analysis package in sequence as detailed below using section separators. Attach all raw data to every form generated, to include manual integration(s) and re-analysis.

- Case Narrative
- Sample Results
- LCS/LCSD Summary
- MS/MSD Summary
- ICAL Summary
- ICV Summary
- DCC Summary
- Analytical Run Log
- Sample Preparation
- Non-Conformance Report (if any)

10.8.2. Review the attached logs that they are properly filled.

10.8.3. Perform a 100% data review in accordance to EMAX-DM01 and the PSR.

10.8.3.1. Check QC Criteria

10.8.3.1.1. Check the analytical log that samples are analyzed in conformance to the QC frequency and all pertinent records are logged.

10.8.3.1.2. Check that the following conforms to the QC requirement.

- Holding Time
- Calibrations (IPC, ICC, CCC and ECC)
- $PD_{A/H}$
- LRB
- LFB
- LFM/LFM duplicate

10.8.3.2. Check Qualitative Identification

10.8.3.2.1. Check that positively identified peaks are integrated properly.

10.8.3.2.2. Where manual integration was performed, check that it was done properly and documentation was retained in accordance to EMAX-DM01 Section 4.4.3.

10.8.3.2.3. Check that suspicion of carry-over (if any) was ruled out.

10.8.3.3. Check Quantitation

10.8.3.3.1. Check the calculation for correctness (i.e., that dilution factors, sample and/or extract amount, etc. are factored properly) of sample results.

10.8.3.3.2. Check that correct sample amount and/or extract amounts are properly factored.

10.8.4. Check that the generated reports against the raw data. Check that the analytical data generated indicating positive results are qualitatively and quantitatively correct.

10.8.5. Review the case narrative and check that it accurately describes what transpired in the analytical process. Edit as necessary to reflect essential issues not captured by the case narrative generator program.

10.8.6. Submit the analytical folder for secondary review.

10.9. **Preventive Maintenance**

10.9.1. Perform daily instrument check prior to sample analysis. Refer to Form 300FM – Instrument Maintenance Log.

Maintenance Activity	Description	Frequency
Verification	Prime system and run test injection Clean and inspect sampler and perform pressure test	Daily prior to analysis
Detector Maintenance	Check for leaks and verify the performance of the suppressor.	Daily prior to analysis
Documentation	Record all instrument maintenance performed in the instrument maintenance log.	Daily prior to analysis
IC Pump Maintenance	Replace pump head seal, purge valve seal, and filter assembly frits. Perform wear-in procedure and leak test	Every six months or as necessary
Column Maintenance	Replace column or flush column as necessary. Perform pressure test.	As necessary
System Cleaning	Remove dust from fans and vent covers	Every 6 months or as necessary
Sampler Maintenance	Replace tubing. Lubricate moving parts.	Once a year or as necessary
Inspection	Perform general inspection of the complete system	Once a year

10.9.2. Maintain an inventory of instrument parts and supplies for routinely maintenance.

11.0 QUALITY CONTROL

11.1. Refer to Appendix 1 for all related Quality Control parameters, frequency, acceptance criteria and corrective action.

11.2. **Standard Preparation**

11.2.1. All stock standards must be certified.

11.2.2. Stock standards that are prepared from neat standards shall undergo a QC check to insure at least 96% certified concentration.

11.3. **Sample Preparation**

11.3.1. Prior to conducting any field sample analysis, the sample conductivity must be determined to check if sample dilution or pre-treatment is necessary (Refer to Sections 10.1.2 and 10.1.3)

11.3.2. When a sample or samples have been pretreated, a pretreated LRB and LFB must be prepared and analyzed in the same manner as the samples. This is to confirm the absence of any background effect from the pretreatment process.

11.4. **Analytical Batch**

11.4.1. Initial calibration must be established and verified by an ICCS and continuing calibration checks as described in Appendix 1.

11.4.2. An analytical batch shall consist of IPC, QC samples and field samples bracked by CCCS and ECCS every 10 field samples.

11.4.3. DI water shall be used for method blank.

11.5. **Method QC**

11.5.1. A valid LOD and LOQ must be established before the analytical procedure can be used (Refer to Section 3.1). Verification must be done regularly as prescribed in EMAX-QA04.

11.5.2. Retention Time Window must be established and updated as prescribed in Section 10.3.3.

11.5.3. A demonstration of accuracy and precision from seven (7) replicate LFBs shall be established before the analytical procedure can be used.

11.5.4. All analysts conducting this analysis must have established demonstration of capability.

12.0 CORRECTIVE ACTION

12.1. Corrective actions associated with this analytical procedure are described in the Summary of Quality Control Procedures (Refer to Appendix 1).

12.2. **Sample Preparation QC**

12.2.1. For insufficient amount of sample, initiate a NCR and inform the PM immediately.

12.2.2. When laboratory reagent blank is non-compliant, investigate the source of the problem and institute resolution to correct, minimize or eliminate the problem.

12.2.3. If the analyte found in the blank is not detected in any of the field samples, consult with the Supervisor and the PM if the result can be reported. Otherwise, re-analyzed the method blank with the associated samples.

12.2.4. If the reagents that did not undergo quality control check were accidentally used, consider the following to correct the problem.

- Check that there was no data integrity impact. Otherwise, repeat the analysis of all associated samples with new QC samples using QC'd reagent.
- If method blank is clean, use that data to document the solvent or reagent QC.

12.3. **Sample Analysis QC**

12.3.1. When QCS is non-compliant and suggested considerations in the instrument manual do not correct the problem, consult with the Supervisor for further advice prior to performing a new LCR.

12.3.2. When flushing does not get rid of carry-over, consider changing the column and/or the tubings.

12.3.3. If the reagent water shows contamination in the instrument or laboratory reagent blank consider changing the filters of the reagent water source.

12.4. **Method QC**

12.4.1. When LOD verification is non-compliant, consider instrument maintenance or repeat the MDL study.

12.4.2. When retention time significantly shifts, check for blockage or leaks.

12.5. Document the out-of-control event and corrective action in the analytical logbook. If the problem persists, consult the supervisor.

12.6. For other out-of-control events, inform the supervisor for further instruction. If a non-conformance report is necessary, refer to EMAX-QA08 for NCR details.

13.0 POLLUTION PREVENTION

13.1. Observe all necessary precautions to avoid spillage of solvent that may go to wastewater drains.

13.2. Prepare all standards in fume hoods.

14.0 WASTE MANAGEMENT

14.1. Place all residual samples from analysis to a designated satellite waste container for proper disposal.

14.2. No samples maybe dumped on the laboratory sink.

14.3. Dispose all unused samples, expired analytical standards and other waste generated during the analytical process in accordance to EMAX-SM03.

15.0 SUPPLEMENTARY NOTES

15.1. **Definition of Terms**

15.1.1. Batch – is a group of samples that are prepared and/or analyzed at the same time using the same lot of reagents.

15.1.1.1. **Preparation Batch** - is composed of one to 20 samples of the same matrix, a method blank, a lab control sample and matrix spike/matrix spike duplicate.

15.1.1.2. **Analytical batch -** is composed of prepared samples (extracts, digestates, or concentrates), which are analyzed together as a group using an instrument in conformance to the analytical requirement. An analytical batch can include samples originating from various matrices, preparation batches, and can exceed 20 samples.

15.1.2. Detection Limit (DL) - is defined as the smallest analyte concentration that can be demonstrated to be different from zero or a blank concentration at the 99% level of confidence. At the DL, the false positive rate (Type I error) is 1%.

15.1.3. Limit of Detection (LOD) - is defined as the smallest amount or concentration of a substance that must be present in a sample in order to be detected at a high level of confidence (99%). At the LOD, the false negative rate (Type II error) is 1%.

15.1.4. Limit of Quantitation (LOQ) - is at the lowest concentration that produces a quantitative result within specified limits of precision and bias. For DoD projects, the LOQ shall be set at or above the concentration of the lowest initial calibration standard.

15.1.5. Material Safety Data Sheet (MSDS) – is where the physical data, toxicology and safety precaution of a certain substance is listed.

15.1.6. Calibration – is a determinant measured from a standard to obtain the correct value of an instrument output.

15.1.7. Calibration Blank – is a target-analyte-free solvent subjected to the entire analytical process to establish zero baseline or background value.

15.1.8. Instrument Performance Check (IPC) – a standard at 25 µg/L in a solution with conductivity measurement at MCT.

15.1.9. Laboratory Fortified Blank (LFB) – a target-analyte-free sample spiked with a verified known amount of target analyte(s) or a reference material with a certified known value subjected to the entire sample preparation and/or analytical process. LFB is analyzed to monitor the accuracy of the analytical system.

15.1.10. Laboratory Fortified Sample Matrix (LFM) – a sample spiked with a verified known amount of target analyte(s) subjected to the entire sample preparation and/or analytical process. LFM is analyzed to monitor matrix effect on a method's recovery efficiency.

15.1.11. Laboratory Reagent Blank (LRB) – a target-analyte-free sample subjected to the entire sample preparation and/or analytical to monitor contamination.

15.1.12. Linear Calibration Range (LCR) – The concentration range over which the instrument response is linear.

15.1.13. Matrix – is a component or form of a sample.

15.1.14. Matrix Conductivity Threshold (MCT) – The MCT is the matrix conductance where the percent difference of area to peak height ratio of perchlorate in a solution compared to LFB is greater than 20%.

15.1.15. Quality Control Sample (QCS) – A solution obtained from a secondary source different from the source of calibration standard with known concentration of method analytes.

15.1.16. Sample – is a specimen received in the laboratory bearing a sample label traceable to the accompanying COC. Samples collected in different containers having the same field sample ID are considered the same and therefore labeled with the same lab sample ID unless otherwise specified by the project.

15.1.17. Sample Duplicate – is a replicate of a sub-sample taken from one sample, prepared and analyzed within the same preparation batch.

15.1.18. Reagent Water – purified water free from any target analyte or any other substance that may interfere with the analytical process.

15.2. **Application of EMAX QC Procedures**

15.2.1. The procedures and QC criteria summarized in this SOP shall be applied to all projects when performing perchlorate analysis by IC unless other directive is specified by the project requirements.

15.3. **Department of Defense (DoD) Projects**

15.3.1. Samples from DoD sponsored projects shall follow the Quality Assurance Project Plan (QAPP), Statement of Work (SOW) and/or client's quality control directive. In the absence of QAPP, the DoD Quality Systems Manual (QSM), latest update, shall be applied

15.4. **Department of Energy Projects**

15.4.1. Samples from DoE sponsored projects shall follow the Quality Assurance Project Plan (QAPP), Statement of Work (SOW) and/or client's quality control directive. In the absence of QAPP, the DoE Quality Systems for Analytical Services (QSAS), latest update, shall be applied.

15.0 REFERENCES

15.1 Method 314.0, Revision 1.0, November 1999, USEPA Methods for the Determination of Organic and Inorganic Compounds in Drinking Water, Volume 1 (EPA 815-R-00-014)

15.1 EMAX Quality Systems Manual, as updated.

16.0 APPENDICES

16.1 **Figures**

16.1.1. Figure 1 Peak Evaluation Technique

16.1.2. Figure 2 Typical Perchlorate Chromatogram

16.1.3. Figure 3 Typical Instrument Performance Check at MCT

16.1.4. Figure 4 Typical ICAL Summary

16.1.5. Figure 5 Typical Matrix Conductivity Threshold Regression Analysis

16.1.6. Figure 6 Typical Sample Result Summary

16.1.7. Figure 7 Typical LFB Report Summary

16.1.8. Figure 8 Typical LFM Report Summary

16.1.9. Figure 9 Typical Sample Duplicate Report Summary

16.1.10. Figure 10 Typical Case Narrative

16.1 **Appendices**

16.2.1. Appendix 1 Summary of Quality Control Procedures

16.2.2. Appendix 2 Demonstration of Capability

16.2 **Forms**

16.2.1 314.0FA Analysis Log

16.2.2 314.0FM Instrument Maintenance Log

Figure 1: PEAK EVALUATION TECHNIQUE

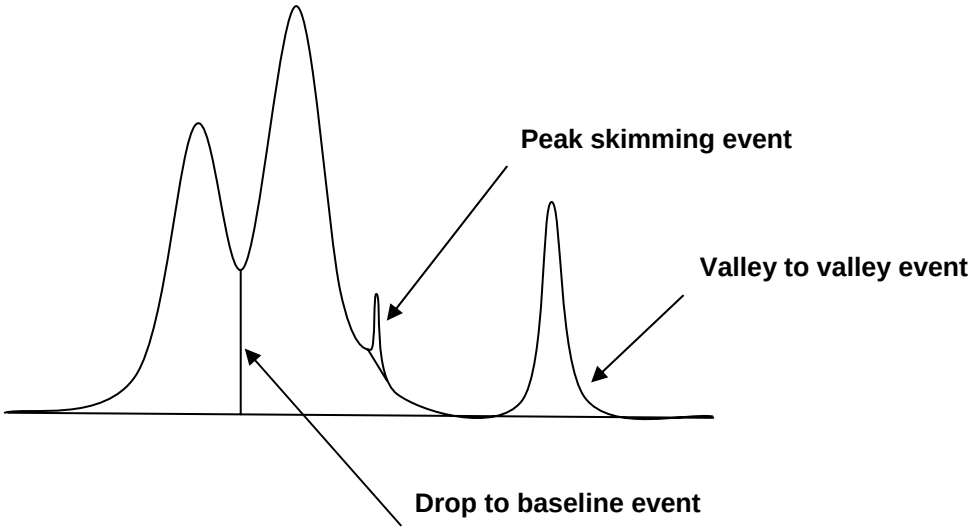


Figure 2: TYPICAL PERCHLORATE CHROMATOGRAM

EPA METHOD 314.0 by IC
EMAX Analytical Laboratories, Inc.

File : c:\ezchrom\chrom\jk03\jk03.004
Method : c:\ezchrom\methods\ic57f24.met
Sample ID : PCK003WL
Acquired : Nov 03, 2011 13:35:22
Printed : Nov 03, 2011 14:26:57
User : CHERRY

Channel A Results

#	Peak Name	R.T.(min)	AREA	HEIGHT	Ave. CF	ESTD Conc.(ppb)	A/H
2	PERCHLORATE	12.63	7527146	347580	290333.688	25.023	21.66

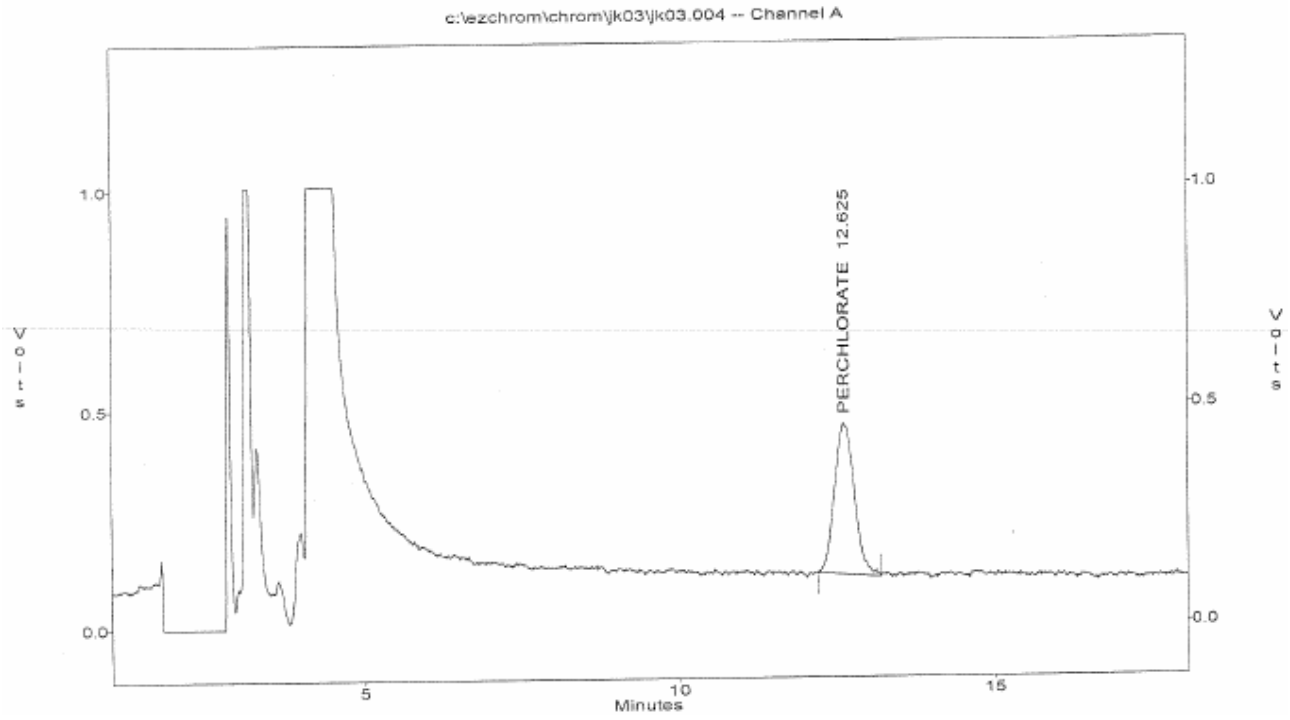


Figure 3: TYPICAL INSTRUMENT PERFORMANCE CHECK AT MCT

EPA METHOD 314.0 by IC
EMAX Analytical Laboratories, Inc.

```
File          : c:\ezchrom\chrom\jk03\jk03.001
Method        : c:\ezchrom\methods\ic57f24.met
Sample ID     : IPCS
Acquired      : Nov 03, 2011 12:32:17
Printed       : Nov 03, 2011 14:25:51
User          : CHERRY
```

Channel A Results

#	Peak Name	R.T.(min)	AREA	HEIGHT	Ave. CF	ESTD Conc.(ppb)	A/H
2	PERCHLORATE	12.51	7085617	284248	290333.688	23.571	24.93

$$PD_{(A/H)} = \frac{|21.66 - 24.93|}{21.66} \times 100 = 15.1\%$$

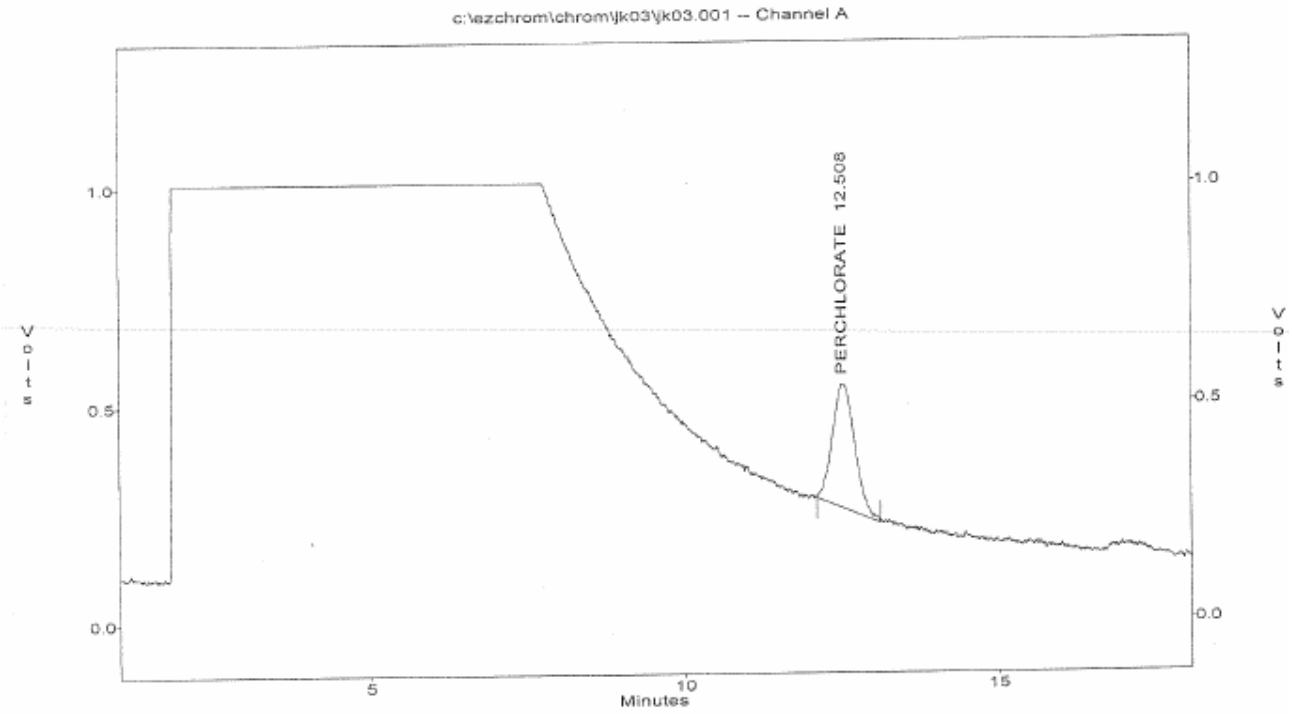


Figure 4: **TYPICAL ICAL SUMMARY**

Method : c:\ezchrom\methods\ic57f24.met
Printed : Jun 27, 2011 09:48:41
Channel : A
Peak : PERCHLORATE

Level	Area	Amount	RF	Rep Area 1	Rep Area 2	Rep Area 3	Rep Area 4	Rep Area 5	Replic STD	Replic %RSD	Old Area
2	536102	2	268051.00	536102							0
3	1152025	4	288006.25	1152025							0
4	2932465	10	293246.50	2932465							0
5	7520627	25	300825.09	7520627							0
6	9046192	30	301539.72	9046192							0

Calib Flag: Replace

Average RF: 290334
RF StdDev: 13657.1
RF %RSD: 4.704

RF Definition: Area / Amount
Weighting Method: None
Fit Through Zero: No

Linear Fit: Amount = 3.29013e-006 x Area + 0.25815
R^2 = 0.999981

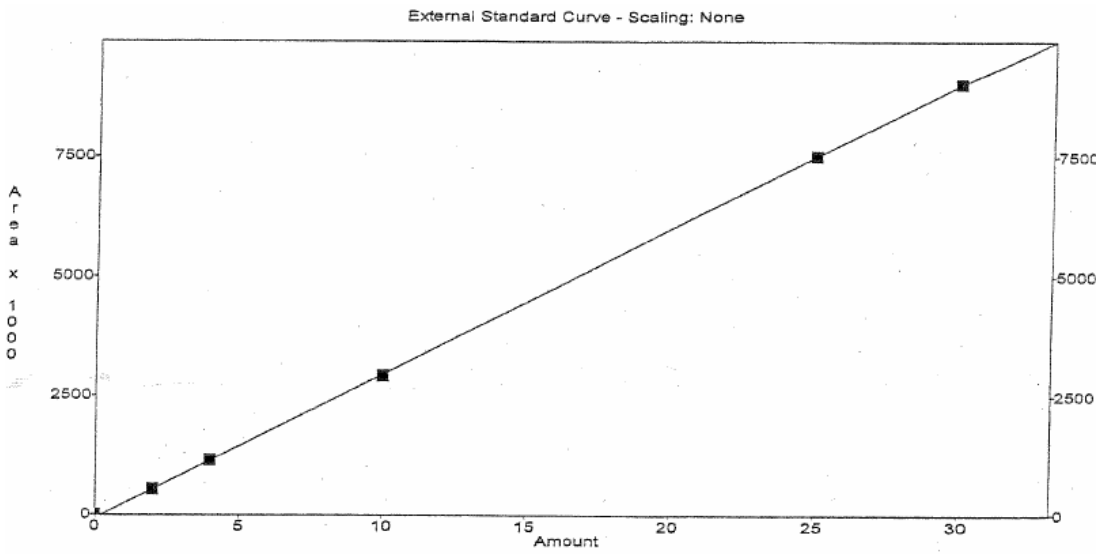
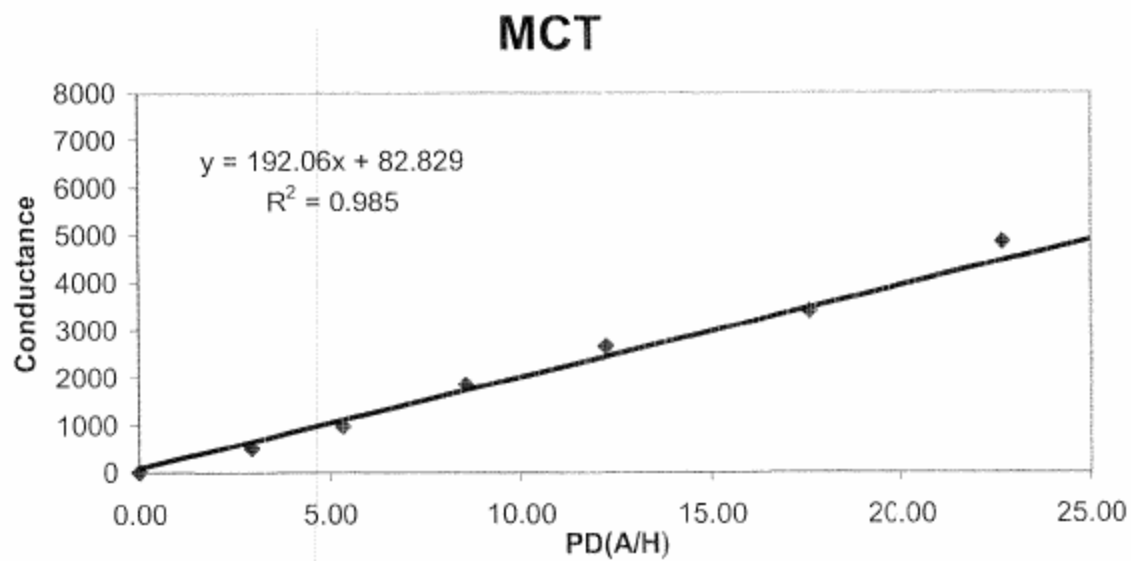
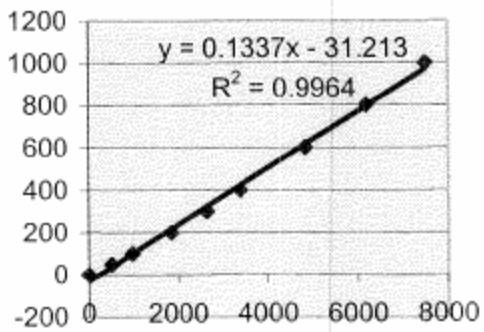


Figure 5: **TYPICAL MATRIX CONDUCTIVITY THRESHOLD REGRESSION ANALYSIS**

MCT	MA (mg/L)	RETENTION TIME	AREA	HEIGHT	A/H	$PD_{A/H}$	EC (uS/cm)	CLO_4 (10ug/L)	% R
0	0	13.41	7224877	313970	23.01136	0.00	1.78	25.207	100.83%
1	50	13.34	7328244	309353	23.68894	2.94	506	25.569	102.28%
2	100	13.35	7472285	308240	24.24178	5.35	977	26.0750	104.30%
3	200	13.32	7288104	291704	24.98459	8.58	1849	25.429	101.72%
4	300	13.32	7328788	283770	25.82651	12.23	2650	25.571	102.28%
5	400	13.26	7299138	269777	27.05619	17.58	3390	25.467	101.87%
6	600	13.24	7171086	254008	28.23173	22.69	4840	25.018	100.07%
7	800	13.23	7626610	245117	31.11416	35.21	6190	26.651	106.60%
8	1000	13.12	6908578	219421	31.48549	36.83	7500	24.097	96.39%





Condct. @ 20% PD(A/H)
3923.029

Conc. @ 20% PD(A/H)
463.54

Figure 6: **TYPICAL SAMPLE RESULT SUMMARY**

METHOD 314.0
PERCHLORATE

Client : XYZ, INC.
Project : CLEAN DRINKING WATER
Batch No. : 11K005
Matrix : WATER
Instrument ID : I57

SAMPLE ID	EMAX SAMPLE ID	RESULTS (ug/L)	DLF	MOIST	RL (ug/L)	MDL (ug/L)	Analysis DATETIME	Extraction DATETIME	LFID	CAL REF	PREP BATCH	Collection DATETIME	Received DATETIME
MBLK1W	PCK002WB	ND	1	NA	2.00	1.00	11/02/1113:24	NA	JK02002	JK02001	PCK002W	NA	NA
LCS1W	PCK002WL	24.3	1	NA	2.00	1.00	11/02/1114:33	NA	JK02004	JK02001	PCK002W	NA	NA
LCD1W	PCK002WC	24.4	1	NA	2.00	1.00	11/02/1114:54	NA	JK02005	JK02001	PCK002W	NA	NA
01-MW102-1-1111	K005-02	2.23	1	NA	2.00	1.00	11/02/1117:16	NA	JK02011	JK02001	PCK002W	10/31/1114:55	11/01/11
MBLK2W	PCK003WB	ND	1	NA	2.00	1.00	11/03/1112:53	NA	JK03002	JK03001	PCK003W	NA	NA
LCS2W	PCK003WL	25.0	1	NA	2.00	1.00	11/03/1113:35	NA	JK03004	JK03001	PCK003W	NA	NA
LCD2W	PCK003WC	24.3	1	NA	2.00	1.00	11/03/1113:56	NA	JK03005	JK03001	PCK003W	NA	NA
01-PZ01-1-1111	K005-03R	4.43	1	NA	2.00	1.00	11/03/1114:17	NA	JK03006	JK03001	PCK003W	10/31/1116:10	11/01/11
01-PZ08-1-1111	K005-04	38.7	2	NA	4.00	2.00	11/03/1114:38	NA	JK03007	JK03001	PCK003W	10/31/1117:20	11/01/11
01-MW201-1-1111	K005-05	202	10	NA	20.0	10.0	11/03/1114:59	NA	JK03008	JK03001	PCK003W	11/01/1109:50	11/01/11
01-EW03-1-1111	K005-06	145	10	NA	20.0	10.0	11/03/1115:20	NA	JK03009	JK03001	PCK003W	11/01/1111:30	11/01/11
01-MW215-1-1111	K005-08	76.2	5	NA	10.0	5.00	11/03/1115:41	NA	JK03010	JK03001	PCK003W	10/31/1113:55	11/01/11
01-MW215-1-1111DUP	K005-08D	76.0	5	NA	10.0	5.00	11/03/1116:02	NA	JK03011	JK03001	PCK003W	10/31/1113:55	11/01/11
01-MW215-1-1111MS	K005-08M	123	5	NA	10.0	5.00	11/03/1116:37	NA	JK03012	JK03001	PCK003W	10/31/1113:55	11/01/11
01-MW223-1-1111	K005-09	70.9	5	NA	10.0	5.00	11/03/1118:58	NA	JK03015	JK03013	PCK003W	10/31/1115:20	11/01/11
01-PZ09-1-1111	K005-10	40.4	2	NA	4.00	2.00	11/03/1119:19	NA	JK03016	JK03013	PCK003W	10/31/1116:20	11/01/11
01-PZ21A-1-1111	K005-11	44.2	2	NA	4.00	2.00	11/03/1119:40	NA	JK03017	JK03013	PCK003W	11/01/1109:50	11/01/11
01-MW219-1-1111	K005-12	124	10	NA	20.0	10.0	11/03/1120:01	NA	JK03018	JK03013	PCK003W	10/31/1115:00	11/01/11
01-MW209-1-1111	K005-16	130	10	NA	20.0	10.0	11/03/1120:43	NA	JK03020	JK03013	PCK003W	11/01/1111:00	11/01/11
MBLK3W	PCK004WB	ND	1	NA	2.00	1.00	11/04/1114:35	NA	JK04002	JK04001	PCK004W	NA	NA
LCS3W	PCK004WL	25.2	1	NA	2.00	1.00	11/04/1115:17	NA	JK04004	JK04001	PCK004W	NA	NA
LCD3W	PCK004WC	26.0	1	NA	2.00	1.00	11/04/1115:38	NA	JK04005	JK04001	PCK004W	NA	NA
01-PZ07-1-1111	K005-14	753	40	NA	80.0	40.0	11/04/1116:20	NA	JK04007	JK04001	PCK004W	11/01/1109:55	11/01/11

Figure 7: **TYPICAL LFB REPORT SUMMARY**

EMAX QUALITY CONTROL DATA
LCS/LCD ANALYSIS

CLIENT: XYZ, INC.
PROJECT: CLEAN DRINKING WATER
BATCH NO.: 11K005
METHOD: METHOD 314.0

MATRIX:	WATER			% MOISTURE:	NA
DILUTION FACTOR:	1	1	1		
SAMPLE ID:	MBLK3W				
LAB SAMP ID:	PCK004WB	PCK004WL	PCK004WC		
LAB FILE ID:	JK04002	JK04004	JK04005		
DATE EXTRACTED:	NA	NA	NA	DATE COLLECTED:	NA
DATE ANALYZED:	11/04/1114:35	11/04/1115:17	11/04/1115:38	DATE RECEIVED:	NA
PREP. BATCH:	PCK004W	PCK004W	PCK004W		
CALIB. REF:	JK04001	JK04001	JK04001		

ACCESSION:

PARAMETER	BLNK RSLT (ug/L)	SPIKE AMT (ug/L)	BS RSLT (ug/L)	BS % REC	SPIKE AMT (ug/L)	BSD RSLT (ug/L)	BSD % REC	RPD (%)	QC LIMIT (%)	MAX RPD (%)
Perchlorate	ND	25.0	25.2	101	25.0	26.0	104	3	85-115	15

Figure 8: TYPICAL LFM REPORT SUMMARY

EMAX QUALITY CONTROL DATA
MS ANALYSIS

CLIENT:	XYZ, INC.			
PROJECT:	CLEAN DRINKING WATER			
BATCH NO.:	11K005			
METHOD:	METHOD 314.0			
MATRIX:	WATER		% MOISTURE:	NA
DILUTION FACTOR:	5	5		
SAMPLE ID:	01-MW215-1-1111			
LAB SAMP ID:	K005-08	K005-08M		
LAB FILE ID:	JK03010	JK03012		
DATE EXTRACTED:	NA	NA	DATE COLLECTED:	10/31/11 13:55
DATE ANALYZED:	11/03/1115:41	11/03/1116:37	DATE RECEIVED:	11/01/11
PREP. BATCH:	PCK003W	PCK003W		
CALIB. REF:	JK03001	JK03001		

ACCESSION:

PARAMETER	SMPL RSLT (ug/L)	SPIKE AMT (ug/L)	MS RSLT (ug/L)	MS % REC	QC LIMIT (%)
Perchlorate	76.2	50.0	123	94	80-120

Figure 9: TYPICAL SAMPLE DUPLICATE REPORT SUMMARY

EMAX QUALITY CONTROL DATA
DUPLICATE SAMPLE ANALYSIS

CLIENT:	XYZ, INC.			
PROJECT:	CLEAN DRINKING WATER			
BATCH NO.:	11K005			
METHOD:	METHOD 314.0			
MATRIX:	WATER		% MOISTURE:	NA
DILUTION FACTOR:	5	5		
SAMPLE ID:	01-MW215-1-1111			
EMAX SAMP ID:	K005-08	K005-08D		
LAB FILE ID:	JK03010	JK03011		
DATE EXTRACTED:	NA	NA	DATE COLLECTED:	10/31/11 13:55
DATE ANALYZED:	11/03/1115:41	11/03/1116:02	DATE RECEIVED:	11/01/11
PREP. BATCH:	PCK003W	PCK003W		
CALIB. REF:	JK03001	JK03001		

ACCESSION:

PARAMETER	SMPL RSLT (ug/L)	DUPL RSLT (ug/L)	RPD RSLT %	QC LIMIT (%)
Perchlorate	76.2	76	0	15

Figure 10: TYPICAL CASE NARRATIVE

CASE NARRATIVE

Client : XYZ, INC.

Project : CLEAN DRINKING WATER

SDG : 11K005

METHOD 314.0
PERCHLORATE

A total of twelve (12) water samples were received on 11/01/11 for Perchlorate by IC analysis, Method 314.0 in accordance with Methods for the Determination of Inorganic Substances in Environmental Samples (EPA/600/R-93/100).

Holding Time
Samples were analyzed within the prescribed holding time except for sample. The sample was analyzed upon client advice to proceed with the analysis.

Calibration
Multi-calibration points were generated to establish initial calibration (ICAL). ICAL was verified using a secondary source. Continuing calibration verifications were carried out at the frequency specified by the project. All calibration requirements were within acceptance criteria.

Method Blank
Method blanks were analyzed at the frequency required by the project. For this SDG, three (3) method blanks were analyzed with the samples. All results were compliant to project requirement. Refer to QC result summary forms for details.

Lab Control Sample
Three (3) sets of LCS/LCD were analyzed with the samples in this SDG.
Percent recoveries for PCK002WL/C were all within QC limits.
Percent recoveries for PCK003WL/C were all within QC limits.
Percent recoveries for PCK004WL/C were all within QC limits.

Matrix QC Sample
Matrix QC sample was analyzed at the frequency prescribed by the project.
Percent recovery for K005-08M was within project QC limits.
Sample duplicate was also analyzed with the samples. RPD was within project limit.

Sample Analysis
Samples were analyzed according to prescribed analytical procedures. All project requirements were met otherwise anomalies were discussed within the associated QC parameter.

Appendix 1: SUMMARY OF QUALITY CONTROL PROCEDURES

QC PROCEDURE	FREQUENCY	ACCEPTANCE CRITERIA	CORRECTIVE ACTION	1st Rev	2nd Rev
Multi-unit calibration for all analytes (ICAL) {Min. 3 pts.}	Initially or when IPC fails to meet the acceptance criteria.	Correlation coefficient (R) ≥ 0.995 for linear regression	Correct the problem then repeat initial calibration.		
Quality Control Sample (QCS) – Second Source	After every initial calibration or quarterly.	Within ± 10% of expected value	Correct the problem then repeat initial calibration.		
Instrument Performance Check (IPC at MCT)	Initially per analytical batch.	$PD_{A/H}$ < 25% %Rec. 80-120% RT shift < 5%	Correct the problem then repeat and repeat analysis.		
Initial Calibration Check Standard (ICCS)	Initially per analytical batch, verify calibration at MRL.	Within ± 25% of expected value.	Correct the problem then repeat initial calibration.		
Continuing Calibration Check Standard (CCC)/End Calibration Check (ECC)	Alternately analyze separate mid and high level CCCS after every 10 samples and at the end (ECCS) of the analytical sequence.	Recover within ± 15% of expected value.	Repeat calibration and re-analyze all samples since last successful calibration.		
Laboratory Reagent Blank (LRB)/Pretreated LRB	One LRB per preparation batch (≤ 20 samples per matrix). Pre-treated LRB required in any analysis batch which have pre-treated samples.	≤ ½ LOQ	Re-prep and re-analyze LRB and all samples process with LRB.		
Laboratory Fortified Blank (LFB)/ Pre-treated LFB	One LFB per preparation batch (≤ 20 samples per matrix). Pre-treated LFB required in any analysis batch which have pre-treated samples.	%Rec = 85 – 115%	Re-prep and re-analyze the LFB and all associated samples		
Laboratory Fortified Matrix (LFM)	One LFM per 20 field samples per matrix	%Rec = 80 – 120%	N/A		
Special LFM	Pre-treated LFM must be prepared from each sample exceeding MCT and requiring pre-treatment	%Rec = 80 -120%	N/A		
Duplicate	One per preparation batch (≤ 20 samples per matrix)	RPD within ± 15%	N/A		
Comments: For flagging criteria refer to PSR.			Reviewed By:		
			Date:		

Appendix 2: **DEMONSTRATION OF CAPABILITY**

DEMONSTRATION OF CAPABILITY
PERCHLORATE BY IC
METHOD EPA 314.0

Unit: µg/L

Instrument ID: I57

Date Analyzed: 11/30/11

Analyzed By: **A. Mai**

PARAMETER	JK30023	JK30024	JK30025	JK30026	JK30027	JK30028	JK30029	True Value (µg/L)	Ave. Conc.	Ave. % Rec.	SD	%RSD	QC Criteria	COMMENTS
	PCK010WL	PCK011WL	PCK012WL	PCK013WL	PCK014WL	PCK015WL	PCK016WL							
Perchlorate	23.3	23.2	23.2	23.0	23.8	24.2	23.8	25	23.5	94	0.436	1.9	90 - 110	Passed

314FA: **ANALYTICAL RUN LOG**

ANALYSIS RUN LOG
for
ION CHROMATOGRAPHY

Page 1

Note: For samples and relevant QCs/Standards analyzed, refer to attached analytical sequence.

NaOH:

Guard II	ID	NA
Ba		
Ag		
H		

Comments:

Book #:	A57-026
Instrument No.:	57
CMC Instrument No.:	29
Pippette ID:	SW8A-02-19
	SW8A-02-20
	SW8A-02-21
Balance ID:	40706360
Analytical Sequence:	
Method File:	
Analytical Batch:	

SOP #	Rev. #
☐ EMAX-300.0M	1
☐ EMAX-314.0	3
☐ EMAX-	

STANDARDS ID	
ICAL	
ICV	
CCV-15	
CCV-30	
LCS	
MS	
IPC	
MRL	
CMC	

CMC Reading (µS/cm)	QC Criteria (µS/cm)	Temp. (°C)
	± 30	

ELECTRONIC DATA ARCHIVAL	
Location	Date
☐ EZ-CHROM	
☐	

Analyzed By:

Date:

314FM: INSTRUMENT MAINTENANCE LOG

EMAX LABORATORIES, INC.

Page 1

INSTRUMENT MAINTENANCE LOG

Instrument No: 57 Month: Year: 201_ Book #: M57-005

Date							
CD 25 Conductivity Detector: SRS (mA)							
Range (µS)							
Method							
Total (µS)							
GP 50 Gradient Pump: Pressure (psi)							
Column Flow (mL/min)							
Method							
Pump Prime							
LC25 Chromatography Oven: on/off							
AS40 Autosampler Setting							
Purge Eluent Pressure (4 psi)							
Regenerant Pressure (15psi)							
Waste Bottle							
Printer							

Troubleshooting							
Problems Encountered							
Return To Specs (Analyst Initial)							

Code	Problems Encountered	Code	Corrective Action

STANDARD OPERATING PROCEDURE

TOTAL ORGANIC CARBON

SOP No.:	EMAX-415.1	Revision No.	3	Effective Date:	07-Nov-11
Prepared By:	Lucita Arzadon			Date:	11/04-11
Approved By:	Kenette Pimentel QA Manager			Date:	11.04.11
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Control Number: 415.1-03

1.0 SCOPE AND APPLICATION

1.1. This method is used to determine total organic carbons (TOC) in an aqueous sample by combustion-infrared technique. This procedure is only applicable to homogenous samples. This SOP is an adaptation of EPA Method 415.1.

2.0 SUMMARY OF METHOD

2.1. An aliquot of acidified sample is injected into the Analyzer, sparged with gas to remove IC content, and heated at 680°C to convert IC to Total Organic Compound.

2.2. **Interference**

2.2.1. Carbonate and bicarbonate carbon represents interference and must be removed or accounted for in the final calculation.

2.2.2. Suspended particles of a liquid sample, or extract is known to alter results.

3.0 DETECTION LIMITS

3.1. **Detection Limit (DL), Limit of Detection (LOD) & Limit of Quantitation (LOQ)**

3.1.1. Refer to EMAX-QA04 for generation, validation and verification of DL, LOD and LOQ.

3.1.2. Established DL, LOD and LOQ are:

Matrix	DL	LOD	LOQ
Water (mg/L)	0.25	0.5	1.0

4.0 DYNAMIC RANGE

4.1. The highest quantifiable range requiring no dilution is equal to the concentration of the highest calibration point. All samples analyzed above this range shall be considered "over range" and shall require dilution to properly quantitate.

4.2. The lowest quantifiable range of diluted samples is equal to the concentration of the lowest calibration point. All diluted samples analyzed below this range shall be considered "under range" and shall require lower dilution factor to properly quantitate.

5.0 SAMPLE HOLDING TIME & PRESERVATION

5.1. **Preservation**

5.1.1. Preserve samples at pH <2 with either HCl or H_2SO_4.

5.1.2. Store samples in plastic or glass containers that prevent any possible carbon contamination.

5.1.3. Store samples at ≤ 6°C without freezing.

5.2. **Holding Time**

5.2.1. Samples are expected to be stable for 28 days.

6.0 ASSOCIATED SOPs

6.1. EMAX-DM01 Data Flow and Review

6.2. EMAX-QA04 Method Detection Limit

6.3. EMAX-QA05 Training

6.4. EMAX-QA08 Corrective Action

6.5. EMAX-QC02 Analytical Standard Preparation

6.6. EMAX-QC06 Calibration of Micropipettes

6.7. EMAX-QC07 Glassware Cleaning

6.8. EMAX-SM03 Waste Disposal

6.9. EMAX-SM04 Analytical and QC Sample Labeling

7.0 SAFETY

7.1. Read all MSDS for chemicals listed in this SOP.

7.2. Treat all reagents, standards, and samples as potential hazards. Observe the standard laboratory safety procedures. Wear protective gear, i.e., lab coat, safety glasses, gloves at all times when performing this procedure.

7.3. If for any reason, solvent and/or other reagents get in contact with your skin or any other part of your body, rinse the affected body part thoroughly with tap water. If irritations persist inform your supervisor immediately so that proper action can be taken.

8.0 INSTRUMENTS, CHEMICALS AND REAGENTS

8.1. **Instruments and Supplies**

8.1.1. Total Organic Carbon Analyzer Model TOC-V_{CPN} or equivalent

8.1.2. Autosampler – ASI-V

8.1.3. Filtering apparatus and 0.45-µm-pore diam filters, preferably HPLC syringe filters or similar.

8.2. **Chemicals and Reagents**

8.2.1. All reagents are reagent grade or better.

8.2.2. Purchased Reagent grade or better.

8.2.3. Hydrochloric Acid, 2M HCl

8.2.4. Sulfuric Acid, concentrated H_2SO_4

8.2.5. Reagent Water

9.0 STANDARDS

9.1. Standard Preparation

9.1.1. Refer to EMAX-QC02 for proper preparation of analytical standards.

9.1.2. Oven dry Potassium Hydrogen Phthalate @ 105°C - 120°C for 1- hour.

9.1.3. Oven dry Sodium Hydrogen Carbonate @ 280°C - 290°C for 1- hour.

9.1.4. All standards are cooled and stored in dessicator.

9.1.5. Other concentration levels may be prepared other than specified below as long as it is compliant to required acceptance criteria.

9.2. Stock Standards

9.2.1. Total Carbon (TC) Standard Solution, 1000 mg/L of Carbon: Dissolve accurately weighed 0.2128 gm of potassium hydrogen phthalate in 100 ml reagent water.

9.2.2. Inorganic Carbon (IC) Standard Solution, 1000 mg/L of Carbon: Dissolve accurately weighed 0.3500 g of sodium hydrogen carbonate and 0.4418 g of sodium carbonate in 100 ml reagent water.

9.3. ICAL Standards

9.3.1. Using a clean 100 ml volumetric flask, prepare ICAL standards as suggested below.

TC/IC Standard	Volume of Stock, ml	TC/IC Standards Conc., mg/L
1	0.1	1
2	0.5	5
3	1.0	10
4	4.0	40
5	8.0	80

9.3.2. All standard solutions are adjusted to the 100 ml volume mark with reagent water.

9.4. Check Standards

9.4.1. Initial Calibration Verification (ICV)

9.4.1.1.1. Using a secondary source standard, prepare ICV standard by diluting 2.5 ml of TC (NPOC) stock standard solution to 100 ml reagent water. The expected value of this is 25 mg/L.

9.4.2. Continuing Calibration Verification (CCV)

9.4.2.1.1. Using the same standard as the ICAL source, prepare CCV standard by diluting 2.5 ml of TC (NPOC) stock standard solution to 100 ml reagent water. The final concentration of the check standard shall be 25 mg/L.

10.0 PROCEDURES

10.1. Sample Preparations

10.1.1. When Dissolved Organic Carbon (DOC) is to be determined, filter the sample prior to injection. Otherwise, aqueous sample is directly injected into the instrument.

10.2. Instrument Parameters

10.2.1. TOC-V_{CPN}

Catalyst Type	TOC High Sensitivity Catalyst
Furnace Temperature	680°C
Gas Flow Rate	150ml/min
Tubing Diameter	0.5 min.
NDR Cell Length	Long
Range	X3
Replicate Injection	2

10.2.2. Autosampler : ASI-V

Tray Type	24 ml vial
Needle	Sample needle
Needle Wash/ flow Line Wash	2
Rack	0 – 93

10.3. Calibration

10.3.1. Analyze the ICAL standards. Refer to Section 9.3.

10.3.2. Generate the calibration curve after the multi-level ICAL analysis is completed.

10.3.3. Analyze ICV to verify the ICAL.

10.3.4. Refer to Appendix 1 for acceptance criteria.

10.4. Analysis

10.4.1. Place ICAL standards, check standards and sample in designated Auto Sampler positions.

10.4.2. Set up calibration(*.cal)\method(*.met)\template(*.tpl) parameters, refer to Shimadzu TOC-VCPN Sections 4.3 to 4.4.

10.4.2.1. If desired calibration\method\template parameter already exist, in C:\Program Files\Shimadzu Corporation\TOC3201, save and rename the templates in their respective folders, such that, 80_9060.cal(4x injections) and/or 80_415.cal(2x injections) as TCI001.cal.

10.4.2.2. Make sure the templates fulfill all project requirements and generate a sequence by opening a new file to include, Calibration curve, Control Calibration Checks and Auto-Generate to program sample positions.

10.4.3. Check background monitor in the instrument menu before starting the analysis. All window should display green check marks.

10.4.4. Set quantitation to average duplicate determination. Refer to NPOC/TOC Criteria Quantitation of TOC results outlined in TOC-V manual Section 5.1.3 and 5.1.5.

10.4.5. Sparge the acidified sample (pH = 2~3) with zero grade air and/or high purity nitrogen gas, to eliminate the IC Component. Measure the TC remaining in the sample and determine the Total Organic Carbon (NPOC).

10.4.6. The ICAL, check standards and samples must be injected in duplication.

10.4.7. Analytical Sequence

10.4.7.1. ICAL

10.4.7.2. ICV

10.4.7.3. Method Blank

10.4.7.4. LCS

10.4.7.5. Maximum of 10 samples including MS and Duplicate

10.4.7.6. CCV

10.5. **Sample Result Evaluation**

10.5.1. Check QC results as soon as the data is available.

- ✓ Check CCVs that they are within the acceptance criteria.
- ✓ Check that the batch QC samples met the acceptance criteria.
- ✓ Check concentration of target analytes. If the response exceeds the calibration range, dilute and re-analyze the sample until the response falls within the calibration range.
- ✓ If any of the above checkpoints indicate a problem, check the specified corrective action in Appendix 1 to determine if re-analysis is necessary. If re-analysis results are the same as the initial result, consult the Supervisor for further action.

10.6. **Calculations**

10.6.1. Calculate for Percent Recovery of LCS

$$\% R = \left[\frac{C_f}{C_o}\right] 100 \qquad \text{Eq.-10.6.1}$$

where:

$\%R$ - is the percent recovery

C_f - is the concentration found

C_o - is the known concentration of spiked solution

10.6.2. Calculate for Percent Recovery of MS

$$\% R = \left[\frac{(C_f - C_s)}{C_o} \right] 100 \qquad \text{Eq.-10.6.2}$$

where:

%R - is the percent recovery

C_f - is the concentration found

C_s - is the concentration of the sample

C_o - is the known concentration of spiked solution

10.6.3. Calculate for Precision

$$RPD = \frac{\left| C_1 - C_2 \right|}{\left(\frac{C_1 + C_2}{2} \right)} \times 100 \qquad \text{Eq.-10.6.3}$$

where:

RPD – Relative Percent Difference

C_1 – Measured concentration of the first sample aliquot

C_2 – Measured concentration of the second sample aliquot

10.6.4. Calculate for Standard Deviation

$$SD = \sqrt{\frac{\sum_{i=1}^{N} (x_i - \bar{x})^2}{N - 1}} \qquad \text{Eq.-10.6.4}$$

where:

SD - is the standard deviation

x_i - is the result at the ith measurement

$\bar{x}$ - is the mean

N - is the number of measurements

10.6.5. Calculate for % Relative Standard Deviation (%RSD)

$$\%RSD = \left[\frac{SD}{ACF} \right] 100 \qquad \text{Eq.-10.6.5}$$

where:

%RSD - is the percent relative standard deviation

SD - is the standard deviation

ACF - is the average calibration factor

10.7. **Data Reduction**

10.7.1. Make a copy of the analytical run log.

10.7.2. Print a copy of the raw data and the QC report.

10.7.3. Highlight the data to be reported.

10.7.4. Collate the reportable data separating the QC results from the sample results.

10.7.5. Keep all other data generated with the analytical folder marked with "For record only".

10.8. **Report Generation**

10.8.1. Generate the method.txt file using WDB5N.exe.

10.8.2. Generate the sample results using MSRB6.exe.

10.8.3. Generate the QC summary using QCIC.exe.

10.8.4. Generate the sample duplicate result using CQ1N.exe.

10.8.5. Generate the case narrative using CN2.exe.

10.9. **Data Review**

10.9.1. Arrange the analysis package in sequence as detailed below.

10.9.1.1. Case Narrative

10.9.1.2. Sample Results

10.9.1.3. LCS/LCD Summary

10.9.1.4. MS/MSD Summary

10.9.1.5. Sample Duplicate Result

10.9.1.6. Calibration Summary

10.9.1.7. Analytical Run Log

10.9.1.8. Non-Conformance Report (if any)

10.9.2. Perform a 100% data review in accordance to EMAX-DM01 and the PSR.

10.9.3. Check that analytical results are generated by the prescribed calibration schedule of the method.

10.9.4. Review the attached logs that they are properly filled.

10.9.5. Check the generated reports against the raw data. Check that the analytical data generated indicating positive results are qualitatively and quantitatively correct.

10.9.6. Review the case narrative and check that it accurately describes what transpired in the analytical process. Edit as necessary to reflect essential issues not captured by the case narrative generator program.

10.9.7. Submit the analytical folder for secondary review.

10.10. **Preventive Maintenance**

10.10.1. Perform daily instrument check prior to sample analysis. Refer to Form 415.1FM – Instrument Maintenance Log.

Maintenance Activity	Description	Frequency
Documentation	Record all instrument maintenance performed in the instrument maintenance log.	Daily prior to analysis
System Cleaning	Remove dust from fans and vent covers	Every 6 months
Parts Maintenance	Replace worn out parts	Every 6 months
Lubrication	Lubricate mechanical parts	Every 6 months
Flow and Waste lines	Inspect flow and waste lines and replace	Every 6 moths or as necessary
Combustion Tube	Change combustion tube	Every 6 moths or as necessary
Absorber	Change CO2 absorber	Every 6 moths or as necessary
Scrubber	Change halogen scrubber	Every 6 moths or as necessary
Humidifier	Change humidifier water	Every 6 months
Inspection	Perform general inspection of the complete system	Once a year

10.10.2. Maintain an inventory of instrument parts and supplies for routinely maintenance.

10.10.3. For troubleshooting refer to the TOC analyzer operations manual or go to http://www.ssi.shimadzu.com/toc_virtualadvisor/ for virtual troubleshooting assistance.

11.0 QUALITY CONTROL

11.1. Refer to Appendix 1 for all related Quality Control parameters, frequency, acceptance criteria and corrective action.

11.2. Properly treat all lab wares used in the sample preparation as specified in EMAX-QC07.

11.3. All analytical standards are prepared fresh on the day the analysis is done. Follow the procedures for all analytical standard preparations as described in EMAX-QC02 and document in the analytical standard preparation log.

11.4. A preparative batch includes a MB, LCS, and a maximum of 20 field original samples unless otherwise specified by the project.

11.5. MS/MSD is analyzed every 10 samples unless otherwise specified by the project.

11.6. In the absence of MS/MSD, a LCS duplicate (LCD) is prepared and analyzed.

11.7. A valid DL and LOD must exist prior to sample analysis. Refer to EMAX-QA04 for details.

11.8. All analysts conducting this analysis must have an established Demonstration of Capability (DOC) as described in EMAX-QA05.

12.0 CORRECTIVE ACTION

12.1. Corrective action for each Quality Control procedure is summarized in Appendix 1.

12.2. When ICAL is not compliant, consider the following suggestions to correct the problem:

12.2.1. If the correlation coefficient (r) is out of acceptance criteria, review the results and identify presence of an outlier.

- If one of the standards returns a bias-low or bias high on all of the analytes then that point is considered an outlier. Prepare a standard at that ICAL point and re-analyze.
- If the highest ICAL point appears to be saturated, drop the highest point and analyze a lower concentration.
- If the lowest point returns a bias low response or the peaks are not distinct and sharp, drop the point and analyze a higher concentration.
- Otherwise, optimize the instrument and repeat the ICAL.

12.3. When ICV or CCV is not compliant, consider the following suggestions to correct the problem:

- Rule out standard degradation. Prepare a fresh standard and re-analyze.
- If response is low check for leak or if gas pressure is low.
- If response is high, run a blank to rule out contamination. If contamination exist, determine the source of contamination and apply necessary measures to correct the problem. Re-analyze all associated samples that had positive detections.
- Otherwise, inform the supervisor for further instruction.

12.4. When MB is not compliant, consider the following suggestions to correct the problem:

- Rule-out instrument contamination by analyzing instrument blank. In the event that instrument contamination is observed perform the following:
  - replace CO_2 absorber
  - replace the Halogen absorber
  - clean the humidifier tubing
  - replace the content of the dilution bottle with a freshly harvested reagent water. Purge the wash line.
  - re-analyze instrument blank
- If problem persist, perform the decontamination procedure as described in the operations manual or go to http://www.ssi.shimadzu.com/toc_virtualadvisor/.
- If no apparent instrument contamination is observed, re-analyze another reagent blank freshly harvested from the reagent water purifier. If problem persist, inform the Supervisor.
- Re-analyze all samples with positive results. Where re-analysis is not possible, flag the data as described by the PSR and discuss in the case narrative.

12.5. When LCS in is not compliant, consider the following suggestions to correct the problem:

- Rule out standard degradation. Prepare a fresh standard and re-analyze.

- If recovery is low check for leak or if gas pressure is low. Apply necessary measures to correct the problem and re-analyze all associated samples. Where re-analysis is not possible, flag the data as described by the PSR and discuss in the case narrative.
- If response is high, run a blank to rule out contamination. If contamination exist, determine the source of contamination and apply necessary measures to correct the problem. Re-analyze all associated samples positive results.
- Otherwise, inform the supervisor for further instruction.

12.6. When MS/MSD in is not compliant, consider the following suggestions to correct the problem:

- Rule out procedural error, e.g., sample was properly spiked, calculations are correct, etc.. If procedural error is apparent, re-analyze MS/MSD.
- If matrix interference is suspected, discuss it in the case narrative.

12.7. For insufficiency of sample(s), inform the Supervisor immediately for further advice.

12.8. Other anomalies encountered during the analytical process not listed in Appendix 1 shall require a non-conformance report (NCR). Refer to EMAX-QA08.

13.0 POLLUTION PREVENTION

13.1. Observe all necessary precautions to avoid spillage of solvent that may go to the wastewater drains.

13.2. Prepare all standards in fume hoods.

14.0 WASTE MANAGEMENT

14.1. No samples maybe dumped on the laboratory sink.

14.2. Place all residual samples from analysis to a designated satellite waste container for proper disposal.

14.3. Dispose all expired analytical standards and other waste generated during the analytical process in accordance to EMAX-SM03.

15.0 SUPPLEMENTARY NOTES

15.1. **Definition of Terms**

15.1.1. Batch – is a group of samples that are prepared and/or analyzed at the same time using the same lot of reagents.

15.1.1.1. **Preparation Batch** - is composed of one to 20 samples of the same matrix, a method blank, a lab control sample and matrix spike/matrix spike duplicate.

15.1.1.2. **Analytical batch -** is composed of prepared samples (extracts, digestates, or concentrates), which are analyzed together as a group using an instrument in conformance to the analytical requirement. An analytical batch can include samples originating from various matrices, preparation batches, and can exceed 20 samples.

15.1.2. Detection Limit (DL) – The lowest concentration or amount of the target analyte that can be identified, measured and reported with confidence that the analyte concentration is not a false positive.

15.1.3. Limit of Detection (LOD) – An estimate of the minimum amount of substance that an analytical process can reliably detect.

15.1.4. Limit of Quantitation (LOQ) – The minimum levels, concentrations or quantities of target variable (e.g., target analyte) that can be reported with a specified degree of confidence.

15.1.5. Material Safety Data Sheet (MSDS) – is where the physical data, toxicology and safety precaution of a certain substance is listed.

15.1.6. Calibration – is a determinant measured from a standard to obtain the correct value of an instrument output.

15.1.7. Calibration Blank – is a target-analyte-free solvent subjected to the entire analytical process to establish zero baseline or background value.

15.1.8. Instrument Method – is a file generated to contain the instrument calibration and instrument parameter settings for a particular analysis.

15.1.9. Method Blank – is a target-analyte-free sample subjected to the entire sample preparation and/or analytical to monitor contamination.

15.1.10. Lab Control Sample (LCS) – is a target-analyte-free sample spiked with a verified known amount of target analyte(s) or a reference material with a certified known value subjected to the entire sample preparation and/or analytical process. LCS is analyzed to monitor the accuracy of the analytical system.

15.1.11. Lab Control Sample Duplicate (LCSD) – is a replicate of LCS analyzed to monitor precision in the absence of MS/MSD sample.

15.1.12. Sample – is a specimen received in the laboratory bearing a sample label traceable to the accompanying COC. Samples collected in different containers having the same field sample ID are considered the same and therefore labeled with the same lab sample ID unless otherwise specified by the project.

15.1.13. Sample Duplicate – is a replicate of a sub-sample taken from one sample, prepared and analyzed within the same preparation batch.

15.1.14. Sub-sample – is an aliquot taken from a sample for analysis. Each sub-sample is uniquely identified by the sample preparation ID.

15.1.15. Matrix – is a component or form of a sample.

15.1.16. Matrix Spike (MS) – is a sample spiked with a verified known amount of target analyte(s) subjected to the entire sample preparation and/or analytical process. MS is analyzed to monitor matrix effect on a method's recovery efficiency.

15.1.17. Matrix Spike Duplicate (MSD) – is a replicate of MS analyzed to monitor precision or recovery.

15.1.18. Reagent Water – is purified water free from any target analyte or any other substance that may interfere with the analytical process.

15.2. **Application of EMAX QC Procedures**

15.2.1. The procedures and QC criteria summarized in this SOP shall be applied to all projects when performing this method. In instances where there is a project or program QAPP, the requirements given in the project shall take precedence over this SOP.

15.3. **Department of Defense (DoD) Projects**

15.3.1. Samples from DoD sponsored projects shall follow the Quality Assurance Project Plan (QAPP), Statement of Work (SOW) and/or client's quality control directive. In the absence of QAPP, the DoD Quality Systems Manual (QSM), latest update, shall be applied.

15.4. **Department of Energy (DOE) Projects**

15.4.1. Samples from DoE sponsored projects shall follow the Quality Assurance Project Plan (QAPP), Statement of Work (SOW) and/or client's quality control directive. In the absence of QAPP, the DoE Quality Systems for Analytical Services (QSAS), latest update, shall be applied.

16.0 REFERENCES

16.1. Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020, (1983).

16.2. SW846 Method 9060A

16.3. Standard Methods for Examination of Water and Wastewater, 20th Edition

16.4. Instructional Manual TOC-VCSH/CSN & TOC-Control V Software TOC-VCPH/CPN

16.5. EMAX Quality Systems Manual, as updated

17.0 APPENDICES

17.1. **Figures**

17.1.1. Figure 1 Typical Raw Data

17.1.2. Figure 2 Typical Sample Result Summary

17.1.3. Figure 3 Typical LCS/LCSD Summary

17.1.4. Figure 4 Typical MS/MSD Summary

17.1.5. Figure 5 Typical Case Narrative

17.2. **Appendices**

17.2.1. Appendix 1 Summary of Quality Control Procedures

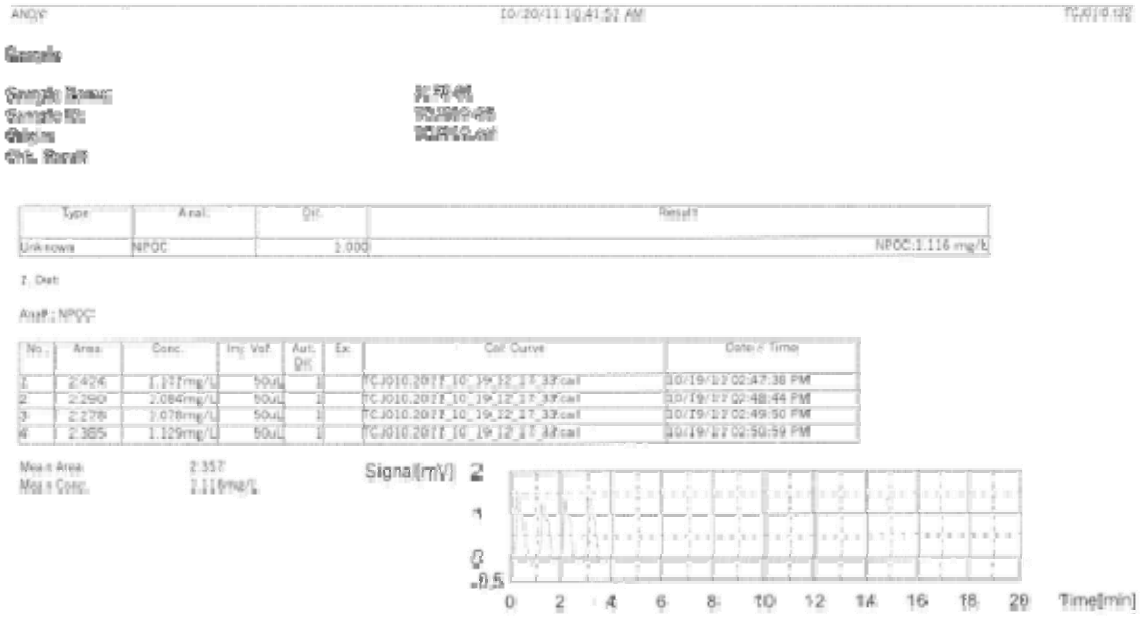
17.2.2. Appendix 2 Demonstration of Capability

17.3. **Forms**

17.3.1. Form 415.1FA Analytical Run Log

17.3.2. Form 415.1FM Instrument Maintenance Log

Figure 1: **TYPICAL RAW DATA**



Type	Anal.	DF	Result
Unknown	NPOC	1.000	NPOC:1.116 mg/L

2. Det

Anal : NPOC

No.	Area	Conc.	Inj. Vol.	Aut. DF	Ex.	Cal. Curve	Date / Time
1	2:424	1.171mg/L	50uL	1		TCJ010.2017_10_19_12_17_33.cal	10/19/17 02:47:38 PM
2	2:290	1.084mg/L	50uL	1		TCJ010.2017_10_19_12_17_33.cal	10/19/17 02:48:44 PM
3	2:278	1.078mg/L	50uL	1		TCJ010.2017_10_19_12_17_33.cal	10/19/17 02:49:50 PM
4	2:385	1.129mg/L	50uL	1		TCJ010.2017_10_19_12_17_33.cal	10/19/17 02:50:59 PM

Mean Area: 2:357
Mean Conc. 1.116mg/L

Figure 2: TYPICAL SAMPLE RESULT SUMMARY

METHOD 415.1
TOC

Client : XYZ, INC.
Project : CLEAN WATER PROJECT
Batch No. : 11J175

Matrix : WATER
Instrument ID : I62

SAMPLE ID	EMAX SAMPLE ID	RESULTS (mg/L)	DLF	MOIST	RL (mg/L)	MDL (mg/L)	Analysis DATETIME	Extraction DATETIME	LFID	CAL REF	PREP BATCH	Collection DATETIME	Received DATETIME
MBLK1W	TCJ014WB	ND	1	NA	1.00	0.500	10/19/1114:13	NA	TCJ010-05	TCJ010-02	TCJ014W	NA	NA
LCS1W	TCJ014WL	26.0	1	NA	1.00	0.500	10/19/1114:26	NA	TCJ010-06	TCJ010-02	TCJ014W	NA	NA
LCD1W	TCJ014WC	26.2	1	NA	1.00	0.500	10/19/1114:40	NA	TCJ010-07	TCJ010-02	TCJ014W	NA	NA
CL2BR	J175-01	1.12	1	NA	1.00	0.500	10/19/1114:50	NA	TCJ010-08	TCJ010-02	TCJ014W	10/16/1108:30	10/16/11
CL2BRMS	J175-01M	26.6	1	NA	1.00	0.500	10/19/1115:03	NA	TCJ010-09	TCJ010-02	TCJ014W	10/16/1108:30	10/16/11
CL2BRMSD	J175-01S	26.7	1	NA	1.00	0.500	10/19/1115:16	NA	TCJ010-10	TCJ010-02	TCJ014W	10/16/1108:30	10/16/11
GW19B	J175-02	1.77	1	NA	1.00	0.500	10/19/1115:27	NA	TCJ010-11	TCJ010-02	TCJ014W	10/16/1110:41	10/16/11
CL3BR	J175-03	1.01	1	NA	1.00	0.500	10/19/1115:38	NA	TCJ010-12	TCJ010-02	TCJ014W	10/16/1112:40	10/16/11
GW19BDUP	J175-04	1.81	1	NA	1.00	0.500	10/19/1115:49	NA	TCJ010-13	TCJ010-02	TCJ014W	10/16/1110:41	10/16/11
CL6BR	J175-05	1.21	1	NA	1.00	0.500	10/19/1116:22	NA	TCJ010-16	TCJ010-14	TCJ014W	10/16/1114:36	10/16/11

Figure 3: TYPICAL LCS/LCSD SUMMARY

EMAX QUALITY CONTROL DATA
LCS/LCD ANALYSIS

CLIENT: XYZ, INC.
PROJECT: CLEAN WATER PROJECT
BATCH NO.: 11J175
METHOD: METHOD 415.1

MATRIX:	WATER			% MOISTURE:	NA
DILUTION FACTOR:	1	1	1		
SAMPLE ID:	MBLK1W				
LAB SAMP ID:	TCJ014WB	TCJ014WL	TCJ014WC		
LAB FILE ID:	TCJ010-05	TCJ010-06	TCJ010-07		
DATE EXTRACTED:	NA	NA	NA	DATE COLLECTED:	NA
DATE ANALYZED:	10/19/1114:13	10/19/1114:26	10/19/1114:40	DATE RECEIVED:	NA
PREP. BATCH:	TCJ014W	TCJ014W	TCJ014W		
CALIB. REF:	TCJ010-02	TCJ010-02	TCJ010-02		

ACCESSION:

PARAMETER	BLNK RSLT (mg/L)	SPIKE AMT (mg/L)	BS RSLT (mg/L)	BS % REC	SPIKE AMT (mg/L)	BSD RSLT (mg/L)	BSD % REC	RPD (%)	QC LIMIT (%)	MAX RPD (%)
TOC	ND	25.0	26.0	104	25.0	26.2	105	1	80-120	20

Figure 4: **TYPICAL MS/MSD SUMMARY**

EMAX QUALITY CONTROL DATA
MS/MSD ANALYSIS

CLIENT: XYZ, INC.
PROJECT: CLEAN WATER PROJECT
BATCH NO.: 11J175
METHOD: METHOD 415.1

MATRIX:	WATER			% MOISTURE:	NA
DILUTION FACTOR:	1	1	1		
SAMPLE ID:	CL2BR				
LAB SAMP ID:	J175-01	J175-01M	J175-01S		
LAB FILE ID:	TCJ010-08	TCJ010-09	TCJ010-10		
DATE EXTRACTED:	NA	NA	NA	DATE COLLECTED:	10/16/11 08:30
DATE ANALYZED:	10/19/1114:50	10/19/1115:03	10/19/1115:16	DATE RECEIVED:	10/16/11
PREP. BATCH:	TCJ014W	TCJ014W	TCJ014W		
CALIB. REF:	TCJ010-02	TCJ010-02	TCJ010-02		

ACCESSION:

PARAMETER	SMPL RSLT (mg/L)	SPIKE AMT (mg/L)	MS RSLT (mg/L)	MS % REC	SPIKE AMT (mg/L)	MSD RSLT (mg/L)	MSD % REC	RPD (%)	QC LIMIT (%)	MAX RPD (%)
TOC	1.12	25.0	26.6	102	25.0	26.7	102	0	80-120	20

Figure 5: TYPICAL CASE NARRATIVE

CASE NARRATIVE

Client : XYZ, INC.

Project : CLEAN WATER PROJECT

SDG : 11J175

METHOD 415.1
TOC

A total of five (5) water samples were received on 10/16/11 for Total Organic Carbon analysis, Method SM5310B in accordance with Methods for the Chemical Analysis of Water and Wastes (MCAWW) (EPA/600/4-79/020).

Holding Time
Samples were analyzed within the prescribed holding time.

Calibration
Multi-calibration points were generated to establish initial calibration (ICAL). ICAL was verified using a secondary source. Continuing calibration verifications were carried out at the frequency specified by the project. All calibration requirements were within acceptance criteria.

Method Blank
Method blank was analyzed at the frequency required by the project. For this SDG, one method blank was analyzed with the samples. Result was compliant to project requirement.

Lab Control Sample
A set of LCS/LCD was analyzed with the samples in this SDG.
Percent recoveries for TCJ014WL/C were all within QC limits.

Matrix QC Sample
Matrix QC sample was analyzed at the frequency prescribed by the project.
Percent recoveries for J175-01M/S were within project QC limits.

Sample Analysis
Samples were analyzed according to prescribed analytical procedures. All project requirements were met otherwise anomalies were discussed within the associated QC parameter.

Appendix 1: SUMMARY OF QUALITY CONTROL PROCEDURES

QC PROCEDURE	FREQUENCY	ACCEPTANCE CRITERIA	CORRECTIVE ACTION	1st Rvw	2nd Rvw
ICAL - Minimum of 5-point calibration	Prior to sample analysis	Correlation coefficient (r) ≥ 0.995	Correct the problem then repeat initial calibration		
Initial Calibration Verification (ICV)	Every after ICAL	%Recovery: ±10% of expected value	Re-analyze ICV to rule out bad injection and/or standard degradation. Otherwise, repeat calibration		
Calibration verification	Every 15 samples and at the end of analysis sequence	%Recovery: ±10% of expected value	Re-analyze CCV to rule out bad injection and/or standard degradation. Otherwise, repeat calibration and reanalyze all samples since last successful calibration verification.		
Method Blank	One per preparation batch	No analytes detected > ½ LOQ	If instrument blank is clean, re-analyze MB and all samples with positive results.		
LCS	One per preparation batch	%Rec: 80-120%	Re-prep and reanalyze the LCS and all associated samples		
MS/MSD	Refer to PSR otherwise, one set every 10 samples	%Rec: 80-120% %D ≤20%	If no procedural error is observed, matrix interference is suspected. Discuss finding in case narrative.		
Comments: Refer to PSR for flagging criteria.			Reviewed By:		
			Date:		

Appendix 2: DEMONSTRATION OF CAPABILITY

DEMONSTRATION OF CAPABILITY
TOTAL ORGANIC CARBON
EPA 415.1

SOP: EMAX-415.1
Conc Unit: mg/L
Sample Amount(ml): 1

Analyzed date: 2/24/2011
Analyzed by: Kyaw Linn

PARAMETER	TCB007-06	TCB007-07	TCB007-08	TCB007-09	TV	Ave. Conc.	Ave. %Rec	SD	RSD (%)	QC Criteria	COMMENTS
	TCB010WL	TCB010WC	TCB011WL	TCB011WC							
TOC	25.45	25.34	25.37	25.27	25	25.36	101	0.075	0.3	80 - 120	PASSED

415.1FA: ANALYTICAL RUN LOG

EMAX LABORATORIES, INC.

ANALYSIS RUN LOG
for
TOC

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	Date	Time
Start		
End		

Note: For samples and relevant QCs/Standards analyzed, refer to attached analytical sequence.

Comments:

2 M HCl

Book #:	A62-018
Instrument No.:	62
Pipette ID:	039380025
	SW3-01-33
	SI1A-01-4
Balance ID:	40706360
Analytical Sequence:	
Method File:	
Analytical Batch:	

SOP #	Rev. #
☐ EMAX-415.1	
☐ EMAX-9060	
☐ EMAX-5310B	
☐ EMAX-	

STANDARDS ID	CONC. (mg/L)
S0	
S1	
S2	
S3	
S4	
S5	
S6	
ICV/LCS	
CCV	

ELECTRONIC DATA ARCHIVAL	
Location	Date
☐ TOC	
☐	

Analyzed By:

Date:

413.1FM: INSTRUMENT MAINTENANCE LOG

EMAX LABORATORIES, INC.

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INSTRUMENT MAINTENANCE LOG

Instrument No: 62 Month: Year: 201_ Book # M62-004

Date							
Air Tank							
Air Pressure (150ml/min)							
Humidifier Water Level							
Pure Water Trap Level							
Rinse Bottle							
Dilution Water Bottle							
External Acid Bottle							
Halogen Scrubber							
CO_2 Absorber							
Background Monitor:							
1) Furnace: 680°C							
2) NDIR: Baseline Position							
Baseline Fluctuation							
Baseline Noise							
3) Dehumidifier: 1.000 reading							
Printer Paper							
Sampler Needle							
Computer Clock							
Analyst Initial							
Trouble Shooting							
Problem(s) Encountered							
Return To Specs (Analyst Initials)							

Code	Problems Encountered	Code	Corrective Action

STANDARD OPERATING PROCEDURES

TRACE METALS BY ICP-MS

SOP No.:	EMAX-6020	Revision No.	8	Effective Date:	27-Jun-13
Prepared By:	Mary Jane Mendoza			Date:	06.27.13
Approved By:	Kenette Pimentel QA Manager			Date:	06-27-13
Approved By:	Caspar Pang Laboratory Director			Date:	06-27-13
				Control Number:	**6020-08**

1.0 SCOPE AND APPLICATION

1.1. This procedure is applicable for the determination of sub-µg/L concentrations of a large number of elements in wastewater, groundwater, aqueous, extract, soil, sludge, and sediment samples using the Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) method. All matrices require proper sample preparation prior to analysis.

1.2. The elements and their corresponding isotopes are listed in Table 1.

1.3. This SOP is an adaptation of the SW846 Method 6020A.

2.0 SUMMARY OF METHOD

2.1. Metal analytes in water are acid digested from a pre-measured sample. Nitric acid and hydrochloric acid are added to the sample and heated without boiling until the volume is substantially reduced. The digestate is diluted back to its original sample volume using reagent water.

2.2. Metal analytes in soil are acid digested from a pre-measured sample. Nitric acid is added to the sample and heated to initialize digestion. It is further oxidized with 30% hydrogen peroxide and the acid used for final reflux is hydrochloric acid.

2.3. Digestates are introduced by pneumatic nebulization resulting aerosol into a high temperature argon plasma, where they are decomposed, atomized and ionized. The ions produced are extracted from the plasma via the sample and skimmer orifices in the interface region of the mass spectrometer. The extracted ions are guided by an off-axis Lens System to reduce background noise, passes through an Octopole Reaction System (ORS) where some ions require a simple reaction with H_2 or He to eliminate matrix interference prior to entering the Quadrupole Mass Filter (QMF). The QMF separates ions based on their mass-to-charge ratios and ions are counted by electron multiplier detector.

2.4. Quantitation is accomplished by comparing the response of a major ion relative to an internal standard using a calibration curve.

2.5. **Interference**

2.5.1. Isobaric Elemental Interference. Are caused by isotopes of different elements which form singly or doubly charge ions of the same nominal mass-to-charge ratio. The signal of an isotope of an interfering element is determined and subtracted from the analyte isotope signal.

2.5.2. Isobaric Polyatomic Ion Interference. Are caused by ions consisting of more than one atom which have the same nominal mass-to-charge ratio as the isotope of interest. To correct for isobaric polyatomic ion interferences, optimize the cell gas pressure on each analyte so that when the ORS employs simple reaction gases (H_2 and He) side reactions create new and unpredictable interferences. The ORS is equipped with notch filters and by using scanning voltages the created interferences are prevented from reaching the analyzer.

2.5.3. Physical Interference. Nebulization and transport processes can be affected if a matrix component causes a change in surface tension or viscosity. An internal standard can be used to correct physical interference if carefully matched to the analyte so that the two elements are similarly affected by matrix changes. When the intensity level of the internal standard is less than 70% of the intensity of the first standard used during calibration, the sample must be diluted and re-analyzed.

2.5.4. Memory Interference. Contamination by carry-over can occur whenever high concentrations are analyzed in sequence with a low concentration sample. To reduce potential carry-over the rinse period between samples must be long enough to eliminate significant memory effect.

3.0 DETECTION LIMITS

3.1. **Detection Limit (DL), Limit of Detection (LOD) & Limit of Quantitation (LOQ)**

3.1.1. Refer to EMAX-QA04 for generation, validation and verification for DL, LOD and LOQ.

3.1.2. Established limits are shown in Table 5.

4.0 DYNAMIC RANGE

4.1. Linear Dynamic Range (LDR) is the concentration over which the instrument response remains linear.

4.2. Establish LDR of each analyte by determining the signal response from a minimum of three preferably five different concentration across the range. The upper limit should be within 10% (± 10%) of the true value.

4.3. Verify the established LDR every six months or when there is a significant change in the instrument signal, whichever comes first.

5.0 SAMPLE HOLDING TIME AND PRESERVATION

5.1. **Holding Time**

5.1.1. Analyze all samples within 180 days from collection date.

5.2. **Preservation**

5.2.1. Expected sample condition when received in the lab:

- water samples in HDPE, preserved to pH < 2 with HNO_3
- soil samples in glass jar or brass tubes

5.2.2. When water sample preservation is requested to be done in the lab, preserve the sample to pH < 2 with HNO_3 and observe at least 24 hours from the time preservative is added before sample digestion.

5.2.3. Store water samples in the same condition as received unless specified in the project requirement.

5.2.4. Store soil samples at ≤ 6°C without freezing.

6.0 ASSOCIATED SOPs

6.1. EMAX-DM01 Data Flow and Review

6.2. EMAX-QA04 Detection Limit (DL)

6.3. EMAX-QA05 Training

6.4. EMAX-QA08 Corrective Action

6.5. EMAX-QC01 Quality Control for Chemicals

6.6. EMAX-QC02 Analytical Standard Preparation

6.7. EMAX-QC04 Balance Calibration

6.8. EMAX-QC05 Calibration of Thermometers

6.9. EMAX-QC06 Calibration of Micropipettes

6.10. EMAX-QC07 Glassware Cleaning

6.11. EMAX-SM03 Waste Disposal

6.12. EMAX-SM04 Analytical and QC Sample Labeling

7.0 SAFETY

7.1. Read all SDS of chemicals listed in this SOP.

7.2. Observe the following precautions during operation or maintenance of the instrument:

- Close the instruments hoods and panels prior to operation.
- Check the exhaust system for a positive extraction at the exhaust duct.
- Handle acids properly.
- Check the drain vessels frequently.
- Make sure that the argon tank is chained.
- Wait for the instrument interface region to cool down prior to instrument maintenance.
- Observe all cautions and warnings stipulated in the Agilent 7500 ICPMS CE/CX Manuals.

7.3. Treat all reagents, standards, and samples as potential hazards. Observe the standard laboratory safety procedures. Wear protective gear, i.e., lab coat, safety glasses, gloves, at all times when performing this procedure. Observe all chemical hygiene procedures as mentioned in the Chemical Hygiene Plan.

7.4. DO NOT DISPOSE ACIDIC WASTE IN THE TRASH CAN OR IN THE SINK.

7.5. If for any reason, solvent and/or other reagents get in contact with the skin or any other part of the body, rinse the affected body part thoroughly with tap water. If irritations persist, inform your supervisor immediately so that proper action can be taken.

8.0 INSTRUMENTS, CHEMICALS AND REAGENTS

8.1. **Instruments and Supplies**

8.1.1. ICP-MS: Agilent 7500CE Octopole Reaction System : Agilent 7500CX Octopole Reaction System

8.1.2. Autosampler: CETAC ASX-520

8.1.3. Computer: IBM Compatible

8.1.4. RF Generator: Agilent RF Generators

8.1.5. Data Acquisition: Agilent Chemstation version B.03.04 or as updated : Agilent Chemstation version B.04.00 or as updated

8.1.6. Autosampler rack(s): 17 x 100 mm, 60 positions

8.1.7. Culture tubes: 17 x 100 mm, polypropylene

8.1.8. Volumetric Flask: 10 ml, 50 ml, 500 ml, 1000 ml

8.1.9. Micropipettes: 1 ml, 0.100 ml, 5 ml

8.1.10. Pipet Tips: 100 - 1000 µl

8.1.11. Polyethylene bottles: 250, 500, 1000 ml

8.1.12. Liquid argon

8.1.13. Hydrogen, Compressed: Ultra-high purity

8.1.14. Helium, compressed: Ultra-high purity

8.1.15. Balance: Sartorius LC 620 S or equivalent

8.1.16. Spatula: Stainless steel or equivalent

8.1.17. Digestion vessel: 50 ml, 100 ml snap seal

8.1.18. Digestion block: Aluminum blocks or equivalent

8.1.19. Thermometer: Range 0 - 110°C

8.1.20. Filter: Whatman #41 or equivalent

8.1.21. Digestate Container: 50 ml polyethylene vessel, 100 ml Corning snap seal or equivalent

8.1.22. Disposable watch glass

8.1.23. ASX press Rapid Sample Introduction System

8.2. **Chemicals and Reagents**

8.2.1. DI water, ASTM Type II or equivalent

8.2.2. Nitric Acid, Trace high purity grade, concentrated

8.2.3. Hydrochloric acid, Trace high purity grade, concentrated

8.2.4. Hydrogen Peroxide, ACS grade (e.g., VW3690-5 from VWR) or equivalent

9.0 STANDARDS

9.1. **Tune Check Standard**

STANDARD	SOURCE	ELEMENTS	CONC. (mg/L)	MATRIX
Tuning Solution	Agilent	Li, Y, Ce, Tl, Co	0.01	2% HNO_3
Tuning Check	High Purity	Co, In, Li, Tl	10	2% HNO_3

Standard	Standard			

9.1.1. Prepare tuning check standard at concentration level suggested below.

STANDARD	Aliquot, (ml)	Final volume (ml)	Final Concentration (mg/L)
Intermediate tuning check standard	0.5	50	0.100

9.2. **Internal Standard (IS)**

9.2.1. Purchase stock internal standard as certified standard at concentration listed below or equivalent.

STANDARD	SOURCE	ELEMENTS	CONC. (mg/L)	MATRIX
IS	Agilent	Li6, Sc, Ge, Rh, In, Tb, Bi, Lu	100	10% HNO_3

9.3. **Calibration Standards**

9.3.1. Calibration Stock Standard

9.3.1.1. Purchase custom-made certified individual and mixed stock standards as listed in the table below or equivalent.

STANDARD	SOURCE	ELEMENTS	CONC. (µg/ml)	MATRIX
ICAL 1	High Purity	As, B, Se, Sr, Tl, Ti, V, Zn, Sb, Mo, Sn	10	2% HNO_3 and Trace HF Acid
ICAL 2	High Purity	Ba, Be, Cd, Cr, Co, Cu, Pb, Li, Mn, Ni, Ag, U	10	2% HNO_3
ICAL 3	High Purity	Al, Fe, K, Ca, Mg, Na	1000	4% HNO_3
Phosphorus	AccuStandard	P	100	Water
Tungsten	AccuStandard	W	100	Water and trace NH_4OH
Zirconium	AccuStandard	Zr	100	2-5% HNO_3
Zinc	High Purity	Zn	1000	2% HNO_3

9.3.2. Calibration Working Standard

9.3.2.1. Prepare working standards as suggested in the table below or equivalent.

Working Standard	Stock Standard Name	Conc. (µg/ml)	Source	Preparation		
				Aliquot (ml)	Final vol. (ml)	Final conc. (µg/ml)
Trace mix	ICAL 1	10	High Purity	1.0	10	1.0
	ICAL 2	10	High Purity	1.0		1.0
Cation Mix	Al	10,000	AccuStandard	2.5	500	50
	Ca	10,000	AccuStandard	2.5		50
	Fe	10,000	AccuStandard	2.5		50

	Mg	10,000	AccuStandard	2.5		50
	K	10,000	AccuStandard	2.5		50
	Na	10,000	AccuStandard	1.25		25
Zn – 10 ppm	Zn	1000	High Purity	0.5	50	10
Zr – 1 ppm	Zr	100	AccuStandard	0.5	50	1.0
W – 1 ppm	W	100	AccuStandard	0.5	50	1.0
Mix 7A	ICAL 1	10	High Purity	1.0	10	1.0
	ICAL 2	10	High Purity	1.0		1.0
	ICAL 3	1000	High Purity	1.0		100

9.3.3. Matrix Acid Blank (S0)

9.3.3.1. Prepare matrix acid solution by mixing 3% by volume nitric acid and 1% by volume hydrochloric acid in reagent water. Transfer into a clean HDPE bottle and identify the solution as S0.

9.3.3.2. Use this solution for standards or digestate dilutions.

9.3.4. Initial Calibration Standard

9.3.4.1. The initial calibration consists of a blank (S0) and four standards (S1, S2, S3 and S4). Prepare the standards as suggested below. Refer to Table 3 for final concentrations for each analyte. Please note: More standard points may be added at the discretion of the analyst.

Standard Name	ICAL 1 (ml)	ICAL 2 (ml)	Cation Mix (ml)	Trace Mix (ml)	Zn - 10 ppm (ml)	W / Zr – 1 ppm (ml)	P – 100 ppm (ml)	W / Zr – 100 ppm (ml)	Final volume (ml)	Final Concentration (µg/L)
S1	NA	NA	0.050	0.025	0.0025	0.025	0.0125	NA	50	0.5/25/50/1
S2	0.025	0.025	0.500	NA	0.025	0.250	0.025	NA		5/250/500/10/50
S3	0.125	0.125	2.5	NA	0.125	NA	0.125	0.0125		25/1250/2500/50/250
S4	0.250	0.250	5.0	NA	0.250	NA	0.250	0.0250		50/2500/5000/100/500

9.3.5. Continuing Calibration Verification (CCV) Standard

9.3.5.1. Prepare CCV using the stock standards and S0 as suggested below. Refer to Table 3 for final concentrations for each analyte.

Stock Standard	Aliquot (ml)	Final volume (ml)	CCV Final Concentration (µg/ml)
ICAL 1	0.125	50	0.025
ICAL 2	0.125		0.025
Cation Mix	2.500		2.5/1.250
Zn – 10 ppm	0.125		0.050
P	0.125		0.250
Zr	0.0125		0.025
W	0.0125		0.025

9.3.5.2. Prepare intermediate solution for Low Level CCV (LLCCV) using the stock standards and S0 as suggested below. Refer to Table 3 for final concentrations of each analyte.

	Aliquot (ml)	Final volume (ml)	LLCCV Final Concentration (µg/L)
MIX 7A	0.050	50	1.0/100
B – 1 ppm	0.450		9
P – 100 ppm	0.025		50
Sr – 1 ppm	0.050		1
Zn – 10 ppm	0.045		10
Zr – 1 ppm	0.250		5
W – 1 ppm	0.250		5

9.4. **Secondary Source Standard**

9.4.1. Purchase secondary stock standard from a different source as certified standards or equivalent. Refer to list below.

SOURCE	STANDARD	ELEMENTS	CONC. (mg/L)	MATRIX
CPI	EMAX MIX 2	As, Ba, Be, B, Cd, Cr, Co, Cu, Pb, Mn, Ni, Se, Sr, Tl, Ti, V, Zn, Ag, Sb, Mo, Li, U, Sn	10	5% HNO_3 + Tr HF
	EMAX MIX 3	Al, Fe, Ca, Mg, K, Na	1000	5% HNO_3
Phosphorus	CPI	P	1000	0.05% HNO_3
Zirconium	CPI	Zr	100	2% HNO_3
Tungsten	Ultra Scientific	W	10	Water

9.4.2. Secondary Source Working Standard – Prepare a secondary source working standard using S0 as suggested below or equivalent.

Standard	Element	Stock Conc. (mg/L)	Source	Aliquot (ml)	Final Volume (ml)	Final Conc. (mg/L)
Cation Mix 2	Al	10,000	CPI	2.5	500	50
	Ca	10,000	CPI	2.5		50
	Fe	10,000	CPI	2.5		50
	Mg	10,000	CPI	2.5		50
	K	10,000	CPI	2.5		50
	Na	10,000	CPI	1.25		25

9.4.3. Refer to EMAX-QC02 for detailed procedure of standard preparation and labeling.

9.5. **Initial Calibration Verification (ICV)**

9.5.1. Prepare ICV using the secondary stock working standards and S0 as suggested below. Refer to Table 3 for final concentrations for each analyte.

Stock Standard	Aliquot (ml)	Final Volume (ml)	ICV Final conc. (µg/ml)
ICV1	0.150	50	0.030/0.060
Cation Mix 2	3.000		3.000/1.500
P	0.015		0.300
Zr	0.015		0.030
W	0.015		0.030

9.6. **Interference Standards (ICSA/ICSAB)**

9.6.1. Purchase ICS stock standard as mix certified standards at concentration levels listed below.

STANDARD	SOURCE	ELEMENTS	CONC. (mg/L)	MATRIX
6020ICS-0A (ICSA)	Inorganic Ventures	Al, Ca, Fe, Mg, Na, P, K, S	1000	1.4% HNO_3
		C	2000	
		Cl	10000	
		Mo, Ti	20	
6020ICS-0A + (ICSAB) ICAL 1 + ICAL 2	6020ICS-0A	Al, Ca, Fe, Mg, Na, P, K, S	1000	1.4% HNO_3
		C	2000	
		Cl	10000	
		Mo, Ti	20	
	ICAL 1	As, B, Se, Tl, Ti, V, Zn, Sb, Mo, Sn	10	5% HNO_3 + Tr HF
	ICAL 2	Ba, Be, Cd, Cr, Co, Cu, Pb, Li, Mn, Ni, Ag, U	10	5% HNO_3 + Tr HF

9.6.2. Prepare Intermediate ICSA and ICSAB standards at concentration levels suggested below. Refer to Table 3 final concentrations.

Standard	Parent Standard	Aliquot (ml)	Final Volume (ml)	Final Concentration (mg/L)
Intermediate ICSA	6020ICS-0A	5	50	Varied
Intermediate ICSAB	6020ICS-0A	5	50	Varied
	ICAL 1	0.10		
	ICAL 2	0.10		
	Zr	0.010		
	W	0.010		

9.7. **LCS/MS Spike Standard**

9.7.1. Purchase LCS/MS standards as certified custom-mixed.

STANDARD	SOURCE	ELEMENTS	CONC. (mg/L)	MATRIX
ICV 1	CPI	B, Sr, As, Ba, Be, Ag, Cd, Cr, Co, Cu, Tl, Pb, Mn, Ni, Se, V, Zn, Ti, Sb, Mo, Li, U, Sn	10	5% HNO_3+ Tr HF
ICV 2		Al, Fe, Ca, Mg, K, Na	1000	5% HNO_3
Phosphorus	CPI	P	1000	0.05% HNO_3
Zirconium	CPI	Zr	100	2% HNO_3
Tungsten	High Purity	W	10	Water

9.8. **P/A Tuning Standard**

9.8.1. Using the calibration stock standard from 9.3.1, prepare a 50 µg/L and 100 µg/L mixed standard. These standards should also include 50 µg/L and 100 µg/L of internal standard, which can be prepared by using the internal standard stock from 9.2.1.

10.0 PROCEDURES

10.1. **Sample Preparation**

10.1.1. Water Samples

10.1.1.1. Based from the work order, determine the samples to form a preparative batch (not to exceed 20 samples per preparative batch). Withdraw the sample(s) from the sample control room and bring them to the preparation area. Allow the samples to equilibrate at room temperature.

10.1.1.2. Shake the sample container. Pour a small amount of sample into the sample cap and trickle just enough to wet the pH indicator strip. Compare the color of the wet strip to the indicator chart displayed in the pH indicator box. Record the pH in the digestion log. If the pH value is <2, proceed to 10.1.3. If the pH value is ≥2, check if special instruction is written on the analysis folder or in the COC. Otherwise, fill out an NCR and inform the supervisor immediately. DO NOT PROCEED WITH THE DIGESTION. WAIT FOR FURTHER INSTRUCTION.

10.1.1.3. Line up the samples chronologically under the hood. Check and record the lot number of the digestion vessels if it has been verified for accuracy. Take digestion vessels and label each one corresponding to the samples withdrawn and place them in front of each sample making sure that their labels agree. Take four more vessels and label them as preparation blank, LCS, matrix spike and matrix spike duplicate.

10.1.1.4. Mix the sample thoroughly to achieve homogeneity. Fill each digestion vessel up to the 50-ml mark. (The reduction of the volume is due to waste minimization).

10.1.1.5. Record the volume in the digestion log. Use reagent water for blank and LCS.

10.1.1.6. Take another digestion vessel; fill it with tap water to 50 ml mark. Put a thermometer inside and let it sit on the digestion block. Turn the thermostat to a pre-determined mark to deliver heat at 90°C - 95°C. Record the temperature reading in the digestion log.

10.1.1.7. **Standard Addition**

10.1.1.7.1. Call for a witness for standard addition. Have the witness verify the setting of the micropipette and the expiration dates of the spike standards.

10.1.1.7.2. Add 0.125 ml of each from EMAX MIX 2 and 3 (see Section 9.4.1) solutions to matrix spike samples and LCS. If Phosphorus, Zirconium and Tungsten are target analytes, add 0.0125 ml of each standard.

10.1.1.8. **Acid Digestion for Dissolved Metals**

10.1.1.8.1. Add 0.5 ml of concentrated HNO_3 and 0.25 ml concentrated HCl to each of the digestion vessels.

10.1.1.8.2. Cap the digestion vessels with disposable watch glass.

10.1.1.8.3. Check that the temperature of the digestion block is ≈ 95°C (covered vessel) and adjust if necessary.

10.1.1.8.4. Place the digestion vessels on the digestion block and reduce volume of sample by continuous heating without boiling for two hours.

10.1.1.8.5. Reflux gently for another 15 minutes. Remove the digestion vessels from the digestion plate and allow the vessels to cool down.

10.1.1.8.6. Using a reagent water wash bottle, rinse the disposable watch glass collecting the rinsate on the same digestion vessel that it covered. Add 1.0 ml concentration HNO_3 and 0.25 ml concentration HCl for matrix matching.

10.1.1.8.7. Dilute the digestate with reagent water to the 50 ml mark of the digestion vessel. Seal the vessel and shake. If the digestate appears to be turbid, pass it through Whatman #41 filter and collect it in a new polyethylene container.

10.1.1.9. **Acid Digestion for Total Recoverable Metals**

10.1.1.9.1. Add 0.5 ml of concentrated HNO_3 and 0.25 ml concentrated HCl to each of the digestion vessels.

10.1.1.9.2. Cap the digestion vessels with disposable watch glass.

10.1.1.9.3. Check that the temperature of the digestion block is ≈ 95°C (covered vessel) and adjust if necessary.

10.1.1.9.4. Place the digestion vessels on the digestion block and reduce volume of sample by continuous heating without boiling for two hours.

10.1.1.9.5. Reflux gently for another 15 minutes. Remove the digestion vessels from the digestion block and allow the vessels to cool down.

10.1.1.9.6. Using a reagent water wash bottle, rinse the disposable watch glass collecting the rinsate on the same digestion vessel that it covered. Add 1.0 ml concentration HNO_3 and 0.25 ml concentration HCl for matrix matching.

10.1.1.9.7. Dilute the digestate with reagent water to the 50 ml mark of the digestion vessel. Seal the vessel and shake. If the digestate appears to be turbid, pass it through Whatman #41 filter and collect it in a new

polyethylene container.

10.1.2. Soil Samples

10.1.2.1. **Sample Handling**

10.1.2.1.1. Based from the work order, determine the samples to form a preparative batch (not to exceed 20 field samples). Withdraw the sample(s) from the sample control room designated for metals analysis (passing # 10 sieve) and bring them to the weighing area. Allow the samples to equilibrate at room temperature.

Note: *Sample homogeneity is crucial in metals analysis. If sample is not solely designated for metals analysis (i.e., sample is to be used for other analysis) and it is apparent that sample particles contain > #10 sieve, inform the Supervisor for further instruction.*

10.1.2.1.2. Take digestion vessels and label each one corresponding to the samples withdrawn. Take four more vessels and label them as preparation blank, LCS, matrix spike and matrix spike duplicate.

10.1.2.1.3. Check project sub-sampling requirement. If multi-incremental sub-sampling (MIS) is required, refer to EMAX-SM01, section 5.13.2 for details. Otherwise follow the steps described in EMAX-SM01, section 5.13.1.

10.1.2.1.4. Scoop 1-2 g sub-sample and transfer into a properly labeled digestion vessel. Record the weight to the nearest 0.01 g.

10.1.2.2. **Pre-heating the Digestion Block**

10.1.2.2.1. Place a digestion vessel with reagent water and a temperature monitoring thermometer on the digestion block.

10.1.2.2.2. Turn the digestion block on and set the thermostat to ~95°C or to a predetermined temperature to obtain approximately 95°C once the digestion vessel is covered with a watch glass.

10.1.2.2.3. When the temperature reading is about 90°-95°C, the digestion block is now ready for digestion.

10.1.2.3. **Standard Addition**

10.1.2.3.1. Call for a witness for standard addition. Have the witness verify the setting of the micropipette and the expiration dates of the spike standards.

10.1.2.3.2. Add 2.5 ml of EMAX MIX 2 & 3 (Sec. 9.4.1) to LCS and matrix spike samples. If Phosphorus and Zirconium are target analytes, add 0.25 ml of each standard. If Tungsten is a target analyte, add 0.025 mL of standard.

10.1.2.4. **Acid Digestion**

10.1.2.4.1. Add 10 ml of reagent water and 5 ml of concentrated HCL[1] into each vessel, swirl the vessel to mix the acid and the sample. Add same amount of acid into a clean and empty vessel and designate it as blank. Insert the vessels in the digestion block(s). Cap the vessels with conical watch glass.

10.1.2.4.2. Check the temperature of the digestion block 90°C-95°C, adjust if necessary. If temperature happens to be ≥ 100°C, adjust the thermostat and wait until temperature falls within 90°C-95°C. Record the temperature reading in the digestion log.

10.1.2.4.3. Place the digestion vessels on the digestion block and reflux for 15 minutes without boiling.

10.1.2.4.4. Transfer the vessels into unheated digestion block and allow the vessels to cool down for at least 5 minutes. Lift the watch glass and add 10-mL of concentrated HNO_3. Place the watch glass back before working on the next vessel.

10.1.2.4.5. Return the vessels to the digestion block and reflux for another 15 minutes.

10.1.2.4.6. Transfer the vessels into unheated digestion blocks and allow the vessels to cool down for at least 5 minutes. Lift the water glass and add 10 ml 1:1 HNO_3. Place the water glass back before working on the next vessel.

10.1.2.4.7. Return the vessels to the digestion block and reflux for another 15 minutes.

10.1.2.4.8. Transfer the vessels into unheated digestion blocks and allow the vessels to cool down for at least 5 minutes.

10.1.2.4.9. Add 2 ml of reagent water. Then add 3 ml of 30% hydrogen peroxide (H_2O_2) to each vessel, swirling each one of them after every addition to initiate peroxide reaction. Continue to add H_2O_2 until the amount added reaches 10 ml.

10.1.2.4.10. Return the vessels to the heated digestion block. Care must be taken to ensure that losses do not occur due to excessive effervescence.

10.1.2.4.11. Continue to reflux the mixture at 90°C-95°C for 15 minutes. Remove the digestion vessels from the digestion block and allow the vessel to cool down for at least 5 mins.

10.1.2.4.12. Lift the watch glass, add 5 ml of concentrated HCl. Swirl the vessel until added reagents are properly mixed with the solution. Place the watch glass before working on the next vessel. Return the vessels into the heated digestion block. Reflux for additional 15 minutes. Subsequently, remove the digestion vessels from the digestion block and allow the vessels to cool down and dilute to 100 ml final volume with reagent water.

[1] Addition of 5 ml HCl is a modification from Method 3050B to enhance recovery of antimony. Refer to Appendix 3 for the comparative study done on ICP-MS.

10.1.2.4.13. Let the digestate settle and centrifuge or filter with Whatman #41 (see 10.1.5) if necessary otherwise digestates are now ready for analysis.

10.1.2.5. **Digestate Filtration**

10.1.2.5.1. Place Whatman #41 filter paper into each funnel resting on holders. Rinse the filter papers with reagent water.

10.1.2.5.2. Place a pre-labeled digestate container under each funnel making sure that the labels are visible.

10.1.2.5.3. Check the labels to make sure that they agree. Pour the digestate into the filter.

10.1.2.5.4. Filter and collect the digestates in the labeled container. The digestates are now ready for analysis.

10.2. **Instrument Parameters**

10.2.1. Set instrument parameters as suggested below.

10.2.2. Plasma Condition

- RF Power: 1500 W
- RF Matching: 1.68 V
- Sample Depth: 8.0 mm
- Torch Height: -0.4 mm
- Torch Vertical: 0 mm
- Carrier Gas: 0.9 L/min
- Make-up Gas: 0.15 L/min Note: Total Carrier and Make-up gas not to exceed 1.1 L/min.
- Peristaltic pump: 0.1 rps
- Spray Chamber (S/C) Temp: 2°C

10.2.3. Ion Lenses

- Extract 1: 0 V
- Extract 2 : -140V
- Omega Bias-ce: -22 V
- Omega Lens-ce: -1.2 V
- Cell Entrance: -26 V
- QP Focus: 2 V
- Cell Exit: -30 V

10.2.4. Octopole Parameters

- Octopole RF: 150 V
- Octopole Bias: -6 V

10.2.5. Q-Pole Parameters

- AMU Gain: 127
- AMU Offset: 125
- Axis Gain: 0.9996
- Axis Offset: 0.04
- QP Bias: -3 V

10.2.6. Detector Parameters

- Discriminator: 8 mV
- Analog HV: 1630 V
- Pulse HV: 990 V

10.2.7. Reaction Cell

- H_2 Gas: 3.0 ml/min
- He Gas: 4 ml/min

10.2.8. Adjust the instrument parameters to optimize the instrument performance in conformance to the tuning requirement.

10.2.9. Print the most current instrument parameters and place in the appropriate binder for easy reference. Replaced instrument parameter set-up should be archived chronologically for future reference and historical record.

10.3. **Calibration**

10.3.1. Instrument Set-Up

10.3.1.1. Set up the ICP-MS with proper operating parameters. Refer to Section 10.3.

10.3.1.2. Ignite the plasma and allow the instrument to become thermally stable for at least 30 minutes.

10.3.1.3. Check the peristaltic pump to deliver a steady flow.

10.3.2. Tuning the Instrument

10.3.2.1. Tune the instrument according to Normal Mode, Hydrogen Mode and Helium Mode without the internal standard. Refer to Section 10.3 for parameters. On the ICP-MS main Menu, go to Instrument and click Tune and run the tuning solution without the internal standard. After about 60 seconds (making sure the solution is in the system) click start and evaluate the counts of the isotopes according to the table below.

Mode	**Range**		
Normal	Li6 ≥ 6400 counts	Y89 ≥ 16000 counts	Tl205 ≥ 9600 counts
Hydrogen	Ar/Ar78 < 10	Y89 ≥ 3000 counts	
Helium	V51/Co59 < 0.6	Co59 ≥ 7000 counts	ArCl-75 < 10 counts

10.3.2.2. If non-compliant, adjust parameters (e.g. Torch height, Torch vertical, Octopole Bias and QP Bias) and repeat the tune process until the required range is met.

10.3.2.3. Click Generate report for a full scan of the tune. Save all tune values to the current method.

10.3.3. Perform a P/A Factor Evaluation

10.3.3.1. Analyze the 50 µg/L P/A Tuning Standard.

10.3.3.2. Under "Tune," access "P/A Factor."

10.3.3.3. Select "Load masses from the acquisition method". Select and delete Ca, $(Cd)^{106}$, $(Cd)^{108}$, $(Pb)^{206}$, $(Pb)^{207}$ from the list of elements.

10.3.3.4. Select "run."

10.3.3.5. When complete accept the changes.

10.3.3.6. Print out P/A Factor and store the printout with the tuning data.

10.3.3.7. Accept the new P/A Factors.

10.3.3.8. Under "file" select "copy tune parameters" and copy the P/A Factors to both the H2 and He modes.

10.3.3.9. Save file as "norm.u".

10.3.4. Perform Tune Check

10.3.4.1. Analyze the intermediate tune check solution (9.1.1) using 4 replicates.

10.3.4.2. Evaluate the tune check so that the mass calibration differs no more than 0.1 AMU of the true value and the resolution to be less than 0.9 AMU full width at 10% peak height RSD should less than or equal to 5% for the 4 replicate analysis.

10.3.5. Initial Calibration (ICAL)

10.3.5.1. Analyze a calibration blank (S0) and a multi-point calibration standard (Section 9.3.3.1).

10.3.5.2. Set the instrument rinse time to 90 seconds between each standard solution.

10.3.5.3. Refer to Appendix 1 for ICAL acceptance criteria and /or corrective action.

10.3.6. Initial Calibration Verification (ICV)/ Instrument Calibration Blank (ICB)

10.3.6.1. Analyze the ICV (Section 9.5.1) from a second source to verify the concentration of the ICAL.

10.3.6.2. Analyze a low-level ICV (LLICV) from the same source as the calibration standard to verify the lower limit of quantitation (RL).

10.3.6.3. Analyze an ICB after LLICV to demonstrate absence of instrument contamination.

10.3.6.4. Refer to Appendix 1 for ICV, LLICVand ICB acceptance criteria and /or corrective action.

10.3.7. Continuing Calibration Verification (CCV)/ Continuing Calibration Blank (CCB)

10.3.7.1. Analyze CCV to check the validity of the ICAL every 10 samples and at the end of the analytical sequence.

10.3.7.2. Analyze low-level CCV (LLCCV) to check the system stability at low end of ICAL at the end of the analytical sequence.

10.3.7.3. Analyze a CCB every after LLCCV to demonstrate the absence of instrument contamination.

10.3.7.4. Refer to Appendix 1 for CCV, LLCCV and CCB acceptance criteria and/or corrective action.

10.3.8. ICSA and ICSAB

10.3.8.1. Analyze ICSA and ICSAB at the beginning of each analytical run and every 12 hours thereafter**.**

10.3.9. Establishing Instrument Detection Limit (IDL)

10.3.9.1. Analyze a minimum of seven consecutive method blanks.

10.3.9.2. Repeat the process within three non-consecutive days.

10.3.9.3. Calculate the standard deviation of each run.

10.3.9.4. The average of the standard deviation of the three runs determines the IDL for each analyte.

10.3.9.5. Establish IDL at least every 3 months.

10.3.10. Verifying Linear Dynamic Range (LDR)

10.3.10.1. Verify the LDR by preparing a standard at the upper limit of the LDR. Analyze and quantitate against the normal calibration curve. Percent recovery must be within ± 10% of expected value. If non-complaint re-establish LDR.

10.3.10.2. At a minimum perform LDR verification every six months.

10.4. **Analysis**

10.4.1. Analytical Sequence

10.4.1.1. From the main menu of the ICPMS top window, go to Sequence and create the analytical sequence by editing the sample log table. Refer to Table 4.

10.4.1.2. Set QC limits on QC samples for easy verification while analytical samples are running.

10.4.1.3. Using the sample log table, input the standards and the digestates to be analyzed. Samples are analyzed in the order they appear in the scanner.

10.4.1.4. Transfer about 5 ml of its content into the autosampler tubes placing them on the autosampler rack in the same order as the analytical sequence. A dilution of x10 for soil samples is required due to the high acid content of the digestate.

10.4.1.5. Dilution Test sample is prepared at 5 times dilution. Seal the tube with Parafilm and invert the tube several times to ensure adequate mixing.

10.4.1.6. Prepare a Post Digestion Spike test sample. Using the un-spiked sample digestate (preferably the QC sample), add MS standard to maintain the same spike level as the MS sample digestate.

10.4.1.7. A 100 µg/L internal standard shall be spiked into each sample.

10.4.1.8. Set the prepared analytical samples into the auto-sampler and start the analytical run.

10.4.2. Sample Result Evaluation

10.4.2.1. Check QC parameters as soon as the data is available.

- Check the initial calibration verification (ICV, LLICV and ICB) against Appendix 1.
- Check MB, LCS against Appendix 1. Perform specified corrective action if necessary.
- Check the MS, duplicate sample, serial dilution and post digestion spike results. If matrix interference is indicated, dilute the sample and re-analyzed.
- Check intensity of internal standard on each sample.
- If any of the above checkpoints is non-compliant, perform the specified corrective action in Appendix 1. If results indicate digestion problem, order re-digestion for affected samples. If unresolved, consult the Supervisor for further action.

10.4.2.2. Check the sample rack to ensure that the Autosampler did not skip any sample.

10.4.2.3. Check concentration of target analytes. If the response exceeds LDR, dilute and reanalyze the sample at a concentration within the LDR.

10.4.2.4. Check other QC requirements like ICSA, ICSAB, CCV, LLCCV, CCB against Appendix 1.

10.5. **Calculations**

10.5.1. The computer software is designed to calculate the concentration in the digestate, based on the assumption that the initial calibration is linear through the origin. Thus, for aqueous samples, the computer-generated result represent the concentration of the sample.

10.5.2. For water samples

$$C_s = C_i\left(\frac{ExpAmt}{Aliquot}\right)\left(\frac{Vd}{ExpVd}\right)DF \qquad \text{Eq.-10.5.2}$$

where:

C_s – Concentration in the sample, µg/L

C_i – Concentration in the digestate, (computer-generated), µg/L

V_d – Digestion volume, ml

ExpVd – Expected digestion volume, ml

DF – Dilution factor

ExpAmt – Expected amount for digestion, ml

Aliquot – Amount digested, ml

10.5.3. For solids, use the following equation to calculate the concentration

$$Cs = C_i\left(\frac{ExpAmt}{Aliquot}\right)\left(\frac{V_d}{ExpVd}\right)\left(\frac{100}{100-\%H_2O}\right)\times DF\times 0.1 \qquad \text{Eq.-10.5.3}$$

where:

C_s – Concentration in the sample, mg/Kg

C_l – Concentration in the digestate (computer-generated), µg/L

V_d – Digestion volume, ml

ExpVd – Expected digestion volume, ml

ExpAmt – Expected amount for digestion, g

Aliquot – Amount digested, g

$\% H_2O$ – Percent moisture of the sample

DF – Dilution factor

0.1 – Conversion factor

10.5.4. Calculate the percent recovery (%R)

$$\% \ Recovery = \frac{Cf - C}{Cs} * 100 \qquad \text{Eq.-10.5.4}$$

where:

C_f – Concentration found, µg/ L

C – Concentration of sample, µg/L

C_s – Concentration of spike, µg/L

10.5.5. Relative Percent Difference (%RPD)

$$RPD = \frac{|C_1 - C_2|}{\left(\frac{C_1 + C_2}{2}\right)} \times 100 \qquad \text{Eq.-10.5.5}$$

where:

RPD – Relative Percent Difference

C_1 – Measured concentration of the first sample aliquot

C_2 – Measured concentration of the second sample aliquot

10.6. **Data Reduction**

10.6.1. Make a copy of the analytical run log and sample preparation log.

10.6.2. Highlight the data to be reported.

10.6.3. Print a copy of the raw data and the QC report.

10.6.4. Keep all other data generated with the analytical folder marked with “For record only” for traceability purpose.

10.7. **Report Generation**

10.7.1. Print the summary of the analytical run, perform a data transfer into a disk, and convert the instrument electronic output file into a CSV file format.

10.7.2. Run the ICPCHK.exe program for calibration check.

10.7.3. Identify samples that need to be re-analyzed, if any, and report all samples that met the analytical requirements.

10.7.4. Generate the report using the following reporting program:

Executable Files	Required Support Files	Output
WDBX[2].exe	Login File (requires network), project.pln, seq_name.sq, seq_name.ckv, seq_name.ckb, seq_name.csv, seq_name.qck, EXCLCMP.LST	Method.txt [this file integrates the login sample information and the analytical sample information]
IF1VX.exe	method.txt, method.met, method.crf, project.pln, project code.txt, qcell.txt	Sample Results (Form1)
IQCICP.exe	method.txt, method.crf, method.qc, project.pln, project code.txt, qcell.txt	QC Summary for LCS and MS (Form 3)
QCX.exe	method.txt, method.crf, method.qc, project.pln, qcell.txt	Summary for Dilution Test (Form 3)
LABCHRNX.exe	method.txt	Lab Chronicle
CN2.exe	Login File, method.txt, Form 1, Form 3	Case Narrative

10.7. **Data Review**

10.8.1. Arrange the analysis package in sequence as detailed below.

- Case Narrative
- Lab Chronicle
- Sample Results
- LCS/LCSD Summary
- MS/MSD Summary
- Sample Duplicate Summary
- Analytical Run Log
- ICAL Summary
- ICV Summary
- CCV Summary

X[2] – latest program version

- Sample Preparation Log
- Non-Conformance Report (if any)

10.8.2. Perform a 100% data review in accordance to EMAX-DM01 and the PSR.

- Review the ICPCHK.exe output file to ensure that it agrees with the instrument output. Check Project Specific Requirement (PSR) or Appendix 1 for acceptance criteria.
- Check frequency of calibration verification. Verify results to be within acceptance limits.
- Check of target analytes concentration to be within linear range.
- Verify interference check results to be within acceptance limits.

10.8.3. If any of the above checkpoints is non-compliant, re-analysis is required.

10.8.4. Review the attached logs that they are properly filled.

10.8.5. Check the generated reports against the raw data. Check that the analytical data generated indicating positive results are qualitatively and quantitatively correct.

10.8.6. Review the case narrative and check that it accurately describes what transpired in the analytical process. Edit as necessary to reflect essential issues not captured by the case narrative generator program.

10.8.7. Submit the analytical folder for secondary review.

10.9. **Preventive Maintenance**

10.9.1. Instruments shall receive routine preventive maintenance that is properly recorded in the instrument-specific maintenance logs. The list of maintenance is summarized in Form 6020FM. The practice ensures optimum operating condition of the equipment thus reducing the possibility of frequent instrument malfunction.

Maintenance Activity	Description	Frequency
Verification	Verify instrument parameters to ensure normal operating conditions. Change tubings as necessary. Perform system tune check. Check instrument performance (e.g., ICV/ICB)	Daily prior to analysis
Vacuum System Maintenance	Inspect vacuum hoses and exhaust tubes for possible problems. Check pump for evidence of leakage	Daily prior to analysis
Documentation	Record all instrument maintenance performed in the instrument maintenance log.	Daily prior to analysis
Ion Lens Cleaning	Remove and clean surfaces of the ion lens. Sonicate ion lens parts	As necessary
System Cleaning	Remove covers and clean dust from fans and vent covers	Every 6 months or as necessary
Pump Maintenance	Replace oil mist filter, drain and replace mechanical pump oil. Verify proper	Every 6 months

	pump operation	
Inspection	Perform general inspection of the complete system	Once a year

11.0 QUALITY CONTROL

11.1. Sample Preparation QC

11.1.1. All labwares used in the sample preparation shall be properly treated as specified in EMAX-QC07.

11.1.2. A preparative batch consists of 20 or fewer samples of the same matrix that are prepared for analysis simultaneously or sequentially, using the same lots of all reagents.

11.1.3. Every preparative batch shall have at least one method blank, one LCS and a set of MS/MSD unless otherwise specified by the project. These QC samples shall be digested together with the field samples.

11.1.4. All reagents shall be subjected to QC check prior to its use. Refer to EMAX-QC01 for details.

11.2. Sample Analysis QC

11.2.1. Perform a tune check before every analytical run, an initial calibration and initial calibration verification (ICV / LLICV). Obtain the ICV standard from a different source from that of the initial calibration and LLICV from the same source as the ICAL. Analyze an instrument calibration blank (ICB) after the LLICV. No further analysis shall be valid unless acceptance criteria are met.

11.2.2. Monitor the intensities of all internal standards for every analysis. Refer to Appendix 1 for acceptance criteria.

11.2.3. Verify inter-element and background correction factors with ICSA and ICSAB standards after ICB every 12 hours.

11.2.4. Verify calibration with continuing calibration verification (CCV) standard and continuing calibration blank (CCB) after every ten samples and at the end of the analytical run. Also verify LLCCV at the end of the analytical run.

11.2.5. Evaluate results of MS/MSD to document matrix interference.

11.2.6. Perform Post Digestion Spike whenever recoveries for MS/MSD failed.

11.2.7. Evaluate Dilution Test result if post digestion spike result failed to meet the acceptance criteria. Failure typically happens when analyte concentrations are high.

11.2.8. Refer to Appendix 1 for acceptance criteria.

11.3. Method QC

11.3.1. A valid DL and LOD must exist prior to sample analysis. Refer to EMAX-QA04 for details.

11.3.2. Perform dynamic range study at least every six months or whenever there is a significant change in instrument response unless otherwise specified by the project.

11.3.3. All analysts conducting this analysis must have an established Demonstration of Capability (DOC) as described in EMAX-QA05.

12.0 CORRECTIVE ACTION

12.1. Quality control procedures and corresponding corrective actions are summarized in Appendix 1.

12.2. If tune is non-compliant, consider the following suggestions to correct the problem:

- Check the instrument settings and make sure that the instrument parameters are properly set up.
- Check argon gas flow.
- Perform auto tune or visual optimization
- If the problem persists, inform the Supervisor.

12.3. If correlation coefficient (R) of ICAL is non-compliant, consider the following suggestions to help you correct the problem:

- Check the calibration points for possible presence of out-lier. If out-lier is present, prepare a fresh standard and repeat the calibration.
- Check the connections and make sure that they are air-tight. Perform maintenance as needed.
  - Presence of bubbles is indicative of poor connection between the sipper and the nebulizer.
  - Poor precision to inability to light the plasma is a symptom of a poor drain tube connection
  - Poor precision and carry-over problems are indicative of a dirty spray chamber.
  - Relative increase in the sensitivity ratio of the higher: lower atomic number elements are indicative of stretched pump tubing. The sample flow rate decreases as the tubing stretches.
- Check the argon gas flow. Loss of signal is indicative of low or no argon gas flow.
- Poor precision and a gradual loss of signal is indicative of “salting-out” in the nebulizer and/or spray chamber due to samples with high dissolved or suspended solids. This problem will necessitate nebulizer and spray chamber cleaning.
- If the problem persists, inform the Supervisor.

12.4. If ICV is non-compliant, consider the following suggestions to help you correct the problem:

- If the RSD is high it is indicative that the carry-over might be present in the spray chamber.
- If result is bias high, prepare a fresh standards and repeat calibration.
- If the problem persists, inform the Supervisor.

12.5. If ICB/CCB is non-compliant, consider the following suggestions to correct the problem:

- Prepare a fresh calibration blank solution. Perform instrument rinsing and repeat the ICB/CCB prior to re-analysis of associated sample(s).
- Carry-over problem is indicative of dirty spray chamber, nebulizer and/or torch. Perform instrument maintenance and repeat the calibration.
- If the problem persists, inform the Supervisor.

12.6. If CCV or LLICV or LLCCV is non-compliant, consider the following suggestions to correct the problem:

- Check the connections prior to re-running the ICAL. Refer to Section 12.3.
- Prepare a new standard and repeat the ICAL.

12.7. If the intensity of the Internal Standard is non-compliant, consider the following suggestions to correct the problem:

- Check for drift occurrence by observing the internal standard intensities in the calibration blank.
- If drift has occurred, terminate the analysis, recalibrate, verify the new calibration and reanalyze the affected samples.
- If drift has not occurred, dilute affected samples five fold and reanalyze with the addition of appropriate amounts of internal standards.

12.8. If Method Blank is non-compliant, consider the following suggestions to correct the problem:

- Rule-out instrument contamination by checking the CCBs. Refer to Section 12.5.
- Rule-out reagent contamination by testing each reagent as described in EMAX-QC01.
- Rule-out digestate vessel contamination by adding verified reagents heating the vessels prior to testing.
  - Common environmental contaminants – Ca, Si, Fe, Na, Mg, K, Tl, Cu, Mn, can be minimized by maintaining the lab clean.
- Other sources of contamination:
  - Sweat contains Ca, Mg, Pb, K, NH_4^+ , SO_4^{-2}, PO_4^{-3}, and Cd (for those who smoke).
  - Cosmetics can contain high concentrations of Al, Be, Ca, Cu, Cr, K, Fe, Mn, Ti, and Zn.
  - Some hair dyes contain $Pb(OAC)_2$.
  - Dandruff shampoo can contain significant levels of Se.
  - Eye make-up may contain Hg as a preservative.
  - Calamine lotion is almost pure ZnO.
  - Watches and jewelry contain an assortment of elements and should not be worn in the laboratory.
- Re-digest MB and the associated samples with reagents free of contamination or with newly opened reagents.
- If the problem persists, inform the Supervisor.

12.9. If LCS is non-compliant, consider the following suggestions to correct the problem:

- If result is bias-high, check the LCS standard by analyzing at the spike level.

  If the LCS check is within 80-120 % of the expected value, check the calibration of the micropipette use for spiking. Re-digest and re-analyze the LCS and the associated samples.

  If the LCS check is not within 80-120%, prepare a fresh LCS standard, re-digest and re-analyze LCS and the associated samples.
- Common Problems with Ag, As, Ba, Pb, and Cr, indicating stock standard degradation, are as follows:

  Low Silver (Ag) recovery is indicative of Chloride contamination causing AgCl precipitation

  Low Arsenic (As) recovery is indicative of loss during sample preparation as volatile oxides (AsO_3) or precipitation as $AsCl_3$

  Low Barium (Ba) recovery is indicative of SO_4or CrO_4 contamination. Barium will form precipitates with HF and H_2SO_4.

High Lead (Pb) recovery is indicative of environmental contamination.

12.10. A Non-Conformance Report (NCR) is required when the following circumstances occur:

- Anomalies other than those specified in Appendix 1 are observed.
- Sample is out of technical holding time.

12.10.1. Refer to EMAX-QA08 for NCR details.

13.0 POLLUTION PREVENTION

13.1. Observe all necessary precautions to avoid spillage of solvent that may go to wastewater drains.

13.2. Prepare all standards in fume hoods.

14.0 WASTE MANAGEMENT

14.1. No sample may be dumped in the laboratory sink.

14.2. Separate and properly identify all unused and expired analytical standards for proper disposal.

14.3. Place all waste generated during the analytical process in properly labeled satellite waste containers for proper collection.

14.4. Dispose all unused samples, digestates, expired analytical standards and other waste generated during the analytical process in accordance to EMAX-SM03.

15.0 SUPPLEMENTARY NOTES

15.1. **Definition of Terms**

15.1.1. Batch – is a group of samples that are prepared and/or analyzed at the same time using the same lot of reagents.

15.1.1.1 **Preparation Batch** - is composed of one to 20 samples of the same matrix, a method blank, a lab control sample and matrix spike/matrix spike duplicate.

15.1.1.1 **Analytical batch -** is composed of prepared samples (extracts, digestates, or concentrates), which are analyzed together as a group using an instrument in conformance to the analytical requirement. An analytical batch can include samples originating from various matrices, preparation batches, and can exceed 20 samples.

15.1.2. Detection Limit (DL) – The lowest concentration or amount of the target analyte that can be identified, measured and reported with confidence that the analyte concentration is not a false positive.

15.1.3. Limit of Detection (LOD) – An estimate of the minimum amount of substance that an analytical process can reliably detect.

15.1.4. Limit of Quantitation (LOQ) – The minimum levels, concentrations or quantities of target variable (e.g., target analyte) that can be reported with a specified degree of confidence.

15.1.5. Safety Data Sheet (SDS) – is where the physical data, toxicology and safety precaution of a certain substance is listed.

15.1.6. Calibration – is a determinant measured from a standard to obtain the correct value of an instrument output.

15.1.7. Instrument Method – is a file generated to contain the instrument calibration and instrument parameter settings for a particular analysis.

15.1.8. Instrument Blank – is a target-analyte-free solvent subjected to the entire analytical process to establish zero baseline or background value.

15.1.9. Method Blank – is a target-analyte-free sample subjected to the entire sample preparation and/or analytical procedure to monitor contamination.

15.1.10. Lab Control Sample (LCS) – is a target-analyte-free sample spiked with a verified known amount of target analyte(s) or a reference material with a certified known value subjected to the entire sample preparation and/or analytical process. LCS is analyzed to monitor the accuracy of the analytical system.

15.1.11. Lab Control Sample Duplicate (LCSD) – is a replicate of LCS analyzed to monitor precision in the absence of MS/MSD sample.

15.1.12. Sample – is a specimen received in the laboratory bearing a sample label traceable to the accompanying COC. Samples collected in different containers having the same field sample ID are considered the same and therefore labeled with the same lab sample ID unless otherwise specified by the project.

15.1.13. Sub-sample – is an aliquot taken from a sample for analysis. Each sub-sample is uniquely identified by the sample preparation ID.

15.1.14. Sample Duplicate – is a replicate of a sub-sample taken from one sample, prepared and analyzed within the same preparation batch.

15.1.15. Matrix – is a physical state of a sample. Most of environmental samples are classified as water, soil or air.

15.1.16. Matrix Spike (MS) – is a sample spiked with a verified known amount of target analyte(s) subjected to the entire sample preparation and/or analytical process. MS is analyzed to monitor matrix effect on a method's recovery efficiency.

15.1.17. Matrix Spike Duplicate (MSD) – is a replicate of MS analyzed to monitor precision or recovery.

15.1.18. Re-analysis – is a repeated analysis from the same extract/digestate or sample, identified with the Lab Sample ID suffixed with "W".

15.1.19. Re-extract/digest – is a repeated sample preparation process identified with the Lab Sample ID suffixed with "R".

15.2. **Application of EMAX QC Procedures**

15.2.1. The procedures and QC criteria summarized in this SOP shall be applied to all projects when performing metals analysis. In instances where there is a project or program QAPP, the requirements given in the project shall take precedence over this SOP.

15.3. **Department of Defense (DoD) Projects**

15.3.1. Samples from DoD sponsored projects shall follow the Quality Assurance Project Plan (QAPP), Statement of Work (SOW) and/or client's quality control directive. In the absence of QAPP, the DoD Quality Systems Manual (QSM), latest update, shall be applied.

15.4. **Department of Energy (DoE) Projects**

15.4.1. Samples from DoE sponsored projects shall follow the Quality Assurance Project Plan (QAPP), Statement of Work (SOW) and/or client's quality control directive. In the absence of QAPP, the DoE Quality Systems for Analytical Services (QSAS), latest update, shall be applied.

16.0 REFERENCES

16.1. "Test Methods for Evaluating Solid Waste, Physical / Chemical Methods", EPA Publication SW-846 Update IV, Method 6020A.

16.2. Determination of Trace Elements in Waters and Wastes by Inductively Coupled Plasma-Mass Spectrometry, Method 200.8 Rev. 5.4, 1994.

16.3. USEPA SW846, Method 3050B, Revision 2, December 1996.

16.4. Title 40 Code of Federal Regulations, Part 136 – Guidelines Establishing Test Procedures for the Analysis of Pollutants, latest edition.

16.5. EMAX Quality Systems Manual, as updated.

17.0 APPENDICES

17.1. **Tables**

17.1.1. Table 1 ICP-MS Elements & Isotopes

17.1.2. Table 2 Calibration Standard and Verification Preparation

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17.3. **Appendices**

17.3.1. Appendix 1 Summary of Quality Control Procedures

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17.4. **Forms**

17.4.1. 6020FS Sample Preparation Log

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Table 1: ICP-MS ELEMENTS & ISOTOPES

ELEMENT	SYMBOL	MASS	Tune Mode	Internal Standard
Aluminum	Al	27	3	Sc45
Antimony	Sb	121	3	In115
Arsenic	As	75	2	Ge72
Barium	Ba	137	3	In115
Beryllium	Be	9	3	Li6
Boron	B	11	3	Li6
Cadmium	Cd	111	3	In115
Calcium	Ca	43	1	Sc45
Chromium	Cr	53	2	Sc45
Cobalt	Co	59	3	Sc45
Copper	Cu	63	2	Sc45
Iron	Fe	57	1	Sc45
Lead	Pb	208	3	Tb159
Lithium	Li	7	3	Li6
Magnesium	Mg	24	3	Sc45
Manganese	Mn	55	3	Sc45
Molybdenum	Mo	95	3	In115
Nickel	Ni	60	2	Sc45
Phosphorus	P	31	3	Sc45
Potassium	K	39	3	Sc45
Selenium	Se	78	1	Ge72
Silver	Ag	107	3	In115
Sodium	Na	23	1	Sc45
Strontium	Sr	88	3	Y89
Thallium	Tl	205	3	Tb159
Tin	Sn	118	3	In115
Titanium	Ti	47	3	Sc45
Tungsten	W	182	3	Tb159
Uranium	U	238	3	Tb159
Vanadium	V	50	2	Sc45
Zinc	Zn	66	3	Ge72
Zirconium	Zr	90	3	Ge72

Tune Mode: 1=Reaction H_2 Mode; 2=Collision He Mode; 3= Normal Mode

Table 2 : CALIBRATION STANDARD AND VERIFICATION PREPARATION

Standard #	Mixed Standard Name	Conc. (µg/ml)	Source	Preparation		
				Aliquot (ml)	Final Vol. (ml)	Final Conc. (µg/ml)
S1	Trace Mix	1	High Purity	0.025	50	0.0005
	Cation Mix	50/25	AccuStandard	0.050		0.050/0.025
	Zn	10	High Purity	0.0025		0.001
	W	1	AccuStandard	0.025		0.0005
	P	100	AccuStandard	0.0125		0.025
	Zr	1	AccuStandard	0.025		0.0005
S2	ICAL 1	10	High Purity	0.025	50	0.005
	ICAL 2	10	High Purity	0.025		0.005
	Cation Mix	50/25	AccuStandard	0.500		0.500/0.250
	Zn	10	High Purity	0.025		0.010
	W	1	AccuStandard	0.250		0.005
	P	100	AccuStandard	0.025		0.050
	Zr	1	AccuStandart	0.250		0.005
S3	ICAL 1	10	High Purity	0.125	50	0.025
	ICAL 2	10	High Purity	0.125		0.025
	Cation Mix	50/25	AccuStandard	2.500		2.500/1.250
	Zn	10	High Purity	0.125		0.050
	W	100	AccuStandard	0.0125		0.025
	P	100	AccuStandard	0.125		0.250
	Zr	100	AccuStandard	0.0125		0.025
S4	ICAL 1	10	High Purity	0.250	50	0.050
	ICAL 2	10	High Purity	0.250		0.050
	Cation Mix	50/25	AccuStandard	5.000		5.000/2.500
	Zn	10	High Purity	0.250		0.100
	W	100	AccuStandard	0.025		0.050
	P	100	AccuStandard	0.250		0.500
	Zr	100	AccuStandard	0.025		0.050
ICV	ICV 1	10	CPI	0.150	50	0.030/0.060
	Cation Mix 2	50/25	CPI	3.000		3.000/1.500
	W	10	Ultra Scientific	0.150		0.030
	P	1000	CPI	0.015		0.300
	Zr	100	CPI	0.015		0.030
CCV	ICAL 1	10	High Purity	0.125	50	0.025
	ICAL 2	10	High Purity	0.125		0.025
	Cation Mix	50/25	AccuStandard	2.500		2.500/1.250
	W	100	AccuStandard	0.0125		0.025
	Zn	10	High Purity	0.125		0.050
	P	100	AccuStandard	0.125		0.250
	Zr	100	AccuStandard	0.0125		0.025
LLICV / LLCCV (water)	Mix 7	1/100	High Purity	0.05	50	0.001/0.1
	Zn	10	AccuStandard	0.045		0.01
	W	1	AccuStandard	0.100		0.002
	P	100	AccuStandard	0.025		0.050
	Zr	1	AccuStandard	0.25		0.005
LLICV / LLCCV (soil)	Mix 7	1/100	High Purity	0.025	50	0.0005/0.05
	Zn	10	AccuStandard	0.0025		0.001
	W	1	AccuStandard	0.100		0.002
	P	100	AccuStandard	0.025		0.050
	Zr	1	AccuStandard	0.250		0.005

Table 3: CALIBRATION STANDARDS CONCENTRATION AND REPORTING LIMIT

ELEMENT	ICAL (µg/L)				ICV (µg/L)	CCV (µg/L)	ICSA (µg/L)	ICSAB (µg/L)	LLICV,LLCCV, LOQ (Water) (µg/L)	LLICV,LLCCV, LOQ (Soil) (mg/Kg)
	S1	S2	S3	S4						
Aluminum	50	500	2500	5000	3000	2500	100000	100000	100	100
Antimony	0.5	5	25	50	30	25	0	20	1	0.5
Arsenic	0.5	5	25	50	30	25	0	20	1	0.5
Barium	0.5	5	25	50	30	25	0	20	1	0.5
Beryllium	0.5	5	25	50	30	25	0	20	1	0.5
Boron	0.5	5	25	50	30	25	0	200	10	10
Cadmium	0.5	5	25	50	30	25	0	20	1	0.5
Calcium	50	500	2500	5000	3000	2500	100000	100000	100	100
Chromium	0.5	5	25	50	30	25	0	20	1	0.5
Cobalt	0.5	5	25	50	30	25	0	20	1	0.5
Copper	0.5	5	25	50	30	25	0	20	1	0.5
Iron	50	500	2500	5000	3000	2500	100000	100000	100	100
Lead	0.5	5	25	50	30	25	0	20	1	0.5
Lithium	0.5	5	25	50	30	25	0	20	2	0.5
Magnesium	50	500	2500	5000	3000	2500	100000	100000	100	100
Manganese	0.5	5	25	50	30	25	0	20	1	0.5
Molybdenum	0.5	5	25	50	30	25	2000	2000	2	0.5
Nickel	0.5	5	25	50	30	25	0	20	1	0.5
Phosphorus	25	50	250	500	300	250	100000	100000	50	50
Potassium	50	500	2500	5000	3000	2500	100000	100000	100	100
Selenium	0.5	5	25	50	30	25	0	20	1	0.5
Silver	0.5	5	25	50	30	25	0	20	1	0.5
Sodium	25	500	2500	5000	3000	2500	100000	100000	100	100
Strontium	0.5	5	25	50	30	25	0	20	2	0.5
Thallium	0.5	5	25	50	30	25	0	20	1	0.5
Tin	0.5	5	25	50	30	25	0	20	1	20
Titanium	0.5	5	25	50	30	25	2000	2000	2	0.5
Uranium	0.5	5	25	50	30	25	0	20	1	0.5
Vanadium	0.5	5	25	50	30	25	0	20	1	0.5
Zinc	1	10	50	1000	60	50	0	20	20	2
Zirconium	0. 5	5	25	50	30	25	0	20	5	5
Tungsten	0.5	5	25	50	30	25	0	20	2	2

Table 4: ICP-MS ANALYTICAL SEQUENCE

RUN ID LABEL	SAMPLE DESCRIPTION	SOLUTION ID LABEL
S0	Calibration Standard 1 (blank)	S0
S3, S4, S5	ICAL Standards	S3, S4, S5
ICV	Initial Calibration Verification	ICV
LLICV	Low Level Initial Calibration Verification	LLICV
ICB	Initial Calibration Blank	ICB
ICSA	Initial Interference Solution A	ICSA
ICSAB	Initial Interference Solution A and B	ICSAB
CCV1	Continuing Calibration Verification #1	CCV
CCB1	Continuing Calibration Blank #1	S0
IMSSSSB[3]	Preparation Blank	
IMSSSSL/C	Lab Control Sample	
Sample 1	Sample 1	
Sample 1M	Sample 1 Matrix Spike	
Sample 1S	Sample 1 Matrix Spike Duplicate	
Sample 1J	Sample 1 Serial Dilution(5x dilution sample 1)	
Sample 1A	Sample 1 Post Digestion spike	
Samples 2 to 4	Sample 2 to Sample 5	
CCV2	Continuing Calibration Verification #2	CCV
CCB2	Continuing Calibration Blank #2	S0
Samples 5 to 14	Maximum of 10 Samples	
CCV3	Continuing Calibration Verification #3	CCV
CCB3	Continuing Calibration Blank #3	S0
Samples 15 to 20	Sample 15 to 20 or a maximum of 10 samples (sample 15 to 24)	
ICSA	Initial Interference Solution A	ICSA
ICSAB	Initial Interference Solution B	ICSAB
CCV4	Continuing Calibration Verification #4	CCV
LLCCV	Low Level Continuing Calibration Verification	LLCCV
CCB4	Continuing Calibration Blank #4	S0

[3] where IMSSSS is the digestion batch reference.

Table 5: DL, LOD, LOQ AND LINEAR RANGE CONCENTRATION LEVELS

ELEMENT	WATER (µg/L)			SOIL (mg/kg)			LINEAR RANGE µg/L
	DL	LOD	LOQ	DL	LOD	LOQ	
Aluminum	10	20	100	5	10	100	125000
Antimony	0.25	0.5	1	0.1	0.2	0.5	3000
Arsenic	0.1	0.2	1	0.05	0.1	0.5	3000
Barium	0.25	0.5	1	0.072	0.1	0.5	3000
Beryllium	0.05	0.1	1	0.05	0.1	0.5	500
Boron	2.5	5	10	2.5	5	10	250
Cadmium	0.1	0.2	1	0.057	0.1	0.5	3000
Calcium	13	25	100	17	20	100	400000
Chromium	0.1	0.2	1	0.05	0.1	0.5	3000
Cobalt	0.1	0.2	1	0.05	0.1	0.5	3000
Copper	0.25	0.5	1	0.1	0.2	0.5	3000
Iron	5	10	100	5	10	100	300000
Lead	0.05	0.1	1	0.05	0.1	0.5	3000
Lithium	0.25	0.5	2	0.139	0.2	0.5	500
Magnesium	5	10	100	10	20	100	150000
Manganese	0.1	0.2	1	0.153	0.2	0.5	3000
Molybdenum	0.25	0.5	2	0.1	0.2	0.5	3000
Nickel	0.1	0.2	1	0.063	0.1	0.5	3000
Potassium	10	20	100	10	20	100	400000
Phosphorus	12.5	25	50	12.5	25	50	400000
Selenium	0.15	0.3	1	0.05	0.1	0.5	3000
Silver	0.1	0.2	1	0.05	0.1	0.5	250
Sodium	25	50	100	10	20	100	300000
Strontium	0.5	1	2	0.05	0.1	0.5	3000
Thallium	0.1	0.2	1	0.05	0.1	0.5	3000
Tin	0.1	0.2	1	5	10	20	3000
Titanium	0.25	0.5	2	0.125	0.25	0.5	3000
Tungsten	0.5	1	2	0.5	1	2	1000
Uranium	0.05	0.1	1	0.05	0.1	0.5	3000
Vanadium	0.25	0.5	1	0.19	0.3	0.5	3000
Zinc	5	10	20	0.683	1	2	3000
Zirconium	1	2	5	1	2	5	2000

Figure 1: **TYPICAL SAMPLE REPORT**

METHOD 6020A
METALS BY ICP-MS

Client	: XYZ, INC.	Date Collected:	11/17/10
Project	: CLEAN PROJECT	Date Received:	11/19/10
SDG NO.	: 10K283	Date Extracted:	11/30/10 17:15
Sample ID:	YWB10-2578	Date Analyzed:	12/03/10 18:05
Lab Samp ID:	K283-10	Dilution Factor:	0.991
Lab File ID:	98L04043	Matrix :	SOIL
Ext Btch ID:	IMK029S	% Moisture :	11.6
Calib. Ref.:	98L04035	Instrument ID :	EMAXTI98

PARAMETERS	RESULTS (mg/kg)	LOD (mg/kg)	LOQ (mg/kg)
Aluminum	18000	112	22.4
Antimony	ND	0.561	0.112
Arsenic	2.03	0.561	0.112
Barium	51.9	0.561	0.112
Beryllium	0.344J	0.561	0.112
Cadmium	ND	0.336	0.112
Calcium	618	112	22.4
Chromium	5.01	0.561	0.112
Cobalt	3.29	0.561	0.112
Copper	3.12	0.561	0.224
Iron	13300	112	22.4
Lead	4.34	0.561	0.112
Magnesium	2750	112	22.4
Manganese	227	0.561	0.112
Molybdenum	1.24	0.561	0.112
Nickel	3.33	0.561	0.112
Potassium	2050	112	22.4
Selenium	0.188J	0.561	0.112
Silver	ND	0.561	0.112
Sodium	ND	112	22.4
Thallium	0.236J	0.561	0.112
Vanadium	30.0	0.561	0.112
Zinc	28.9	1.12	0.561

Figure 2: **TYPICAL LCS/LCD SUMMARY**

EMAX QUALITY CONTROL DATA
LCS/LCD ANALYSIS

CLIENT: XYZ, INC.
PROJECT: CLEAN PROJECT
SDG NO.: 10K283
METHOD: METHOD 6020A

MATRIX:	SOIL			% MOISTURE:	NA
DILTN FACTR:	1	1	1		
SAMPLE ID:	MBLK1S				
CONTROL NO.:	IMK029SB	IMK029SL	IMK029SC		
LAB FILE ID:	98L04037	98L04038	98L04039		
DATIME EXTRCTD:	11/30/1017:15	11/30/1017:15	11/30/1017:15	DATE COLLECTED:	NA
DATIME ANALYZD:	12/03/1017:41	12/03/1017:45	12/03/1017:49	DATE RECEIVED:	11/30/10
PREP. BATCH:	IMK029S	IMK029S	IMK029S		
CALIB. REF:	98L04035	98L04035	98L04035		

ACCESSION:

PARAMETER	BLNK RSLT mg/kg	SPIKE AMT mg/kg	BS RSLT mg/kg	BS % REC	SPIKE AMT mg/kg	BSD RSLT mg/kg	BSD % REC	RPD %	QC LIMIT %	MAX RPD %
Aluminum	ND	2500	2370	95	2500	2400	96	1	80-120	20
Antimony	ND	25.0	23.7	95	25.0	23.8	95	1	80-120	20
Arsenic	ND	25.0	23.8	95	25.0	23.5	94	1	80-120	20
Barium	ND	25.0	24.2	97	25.0	24.6	98	2	80-120	20
Beryllium	ND	25.0	23.8	95	25.0	23.9	96	1	80-120	20
Cadmium	ND	25.0	23.5	94	25.0	23.8	95	1	80-120	20
Calcium	ND	2500	2490	99	2500	2490	99	0	80-120	20
Chromium	ND	25.0	24.4	98	25.0	24.7	99	1	80-120	20
Cobalt	ND	25.0	23.8	95	25.0	24.1	96	1	80-120	20
Copper	ND	25.0	24.2	97	25.0	24.4	98	1	80-120	20
Iron	ND	2500	2440	98	2500	2450	98	0	80-120	20
Lead	ND	25.0	24.5	98	25.0	24.4	97	0	80-120	20
Magnesium	ND	2500	2370	95	2500	2390	95	1	80-120	20
Manganese	ND	25.0	23.8	95	25.0	24.0	96	1	80-120	20
Molybdenum	ND	25.0	24.2	97	25.0	24.2	97	0	80-120	20
Nickel	ND	25.0	24.3	97	25.0	24.6	98	1	80-120	20
Potassium	ND	2500	2440	98	2500	2450	98	0	80-120	20
Selenium	ND	25.0	23.8	95	25.0	23.9	95	0	80-120	20
Silver	ND	25.0	23.6	94	25.0	23.9	96	1	80-120	20
Sodium	ND	2500	2460	98	2500	2440	98	1	80-120	20
Thallium	ND	25.0	23.8	95	25.0	24.0	96	1	80-120	20
Vanadium	ND	25.0	24.3	97	25.0	24.5	98	1	80-120	20
Zinc	ND	25.0	25.0	100	25.0	24.7	99	1	80-120	20

Figure 3: TYPICAL MS/MSD SUMMARY

EMAX QUALITY CONTROL DATA
MS/MSD ANALYSIS

CLIENT: XYZ, INC.
PROJECT: CLEAN PROJECT
SDG NO.: 10K283
METHOD: METHOD 6020A

MATRIX:	SOIL			% MOISTURE:	11.6
DILTN FACTR:	0.991	0.992	0.992		
SAMPLE ID:	YWB10-2578				
CONTROL NO.:	K283-10	K283-10M	K283-10S		
LAB FILE ID:	98L04043	98L04040	98L04041		
DATIME EXTRCTD:	11/30/1017:15	11/30/1017:15	11/30/1017:15	DATE COLLECTED:	11/17/10
DATIME ANALYZD:	12/03/1018:05	12/03/1017:53	12/03/1017:57	DATE RECEIVED:	11/19/10
PREP. BATCH:	IMK029S	IMK029S	IMK029S		
CALIB. REF:	98L04035	98L04035	98L04035		

ACCESSION:

PARAMETER	SMPL RSLT mg/kg	SPIKE AMT mg/kg	MS RSLT mg/kg	MS % REC	SPIKE AMT mg/kg	MSD RSLT mg/kg	MSD % REC	RPD %	QC LIMIT %	MAX RPD %
Aluminum	18000	2810	21900	139*	2810	23200	187*	6	80-120	20
Antimony	ND	28.1	23.5	84	28.1	24.5	87	4	80-120	20
Arsenic	2.03	28.1	26.7	88	28.1	27.9	92	5	80-120	20
Barium	51.9	28.1	84.3	116	28.1	90.1	136*	7	80-120	20
Beryllium	0.344J	28.1	26.5	93	28.1	27.0	95	2	80-120	20
Cadmium	ND	28.1	25.8	92	28.1	26.8	95	3	80-120	20
Calcium	618	2810	3330	97	2810	3360	98	1	80-120	20
Chromium	5.01	28.1	31.4	94	28.1	33.1	100	5	80-120	20
Cobalt	3.29	28.1	28.5	90	28.1	29.5	93	3	80-120	20
Copper	3.12	28.1	28.6	91	28.1	29.7	95	4	80-120	20
Iron	13300	2810	17000	131*	2810	18300	176*	7	80-120	20
Lead	4.34	28.1	30.8	94	28.1	32.6	101	6	80-120	20
Magnesium	2750	2810	5550	100	2810	5770	108	4	80-120	20
Manganese	227	28.1	274	170*	28.1	285	207*	4	80-120	20
Molybdenum	1.24	28.1	27.2	93	28.1	28.5	97	5	80-120	20
Nickel	3.33	28.1	29.3	92	28.1	30.7	98	5	80-120	20
Potassium	2050	2810	5000	105	2810	5170	111	3	80-120	20
Selenium	0.188J	28.1	24.4	86	28.1	25.1	89	3	80-120	20
Silver	ND	28.1	26.1	93	28.1	27.0	96	3	80-120	20
Sodium	ND	2810	2620	93	2810	2680	96	2	80-120	20
Thallium	0.236J	28.1	25.9	92	28.1	27.3	96	5	80-120	20
Vanadium	30.0	28.1	58.0	100	28.1	63.4	119	9	80-120	20
Zinc	28.9	28.1	57.7	103	28.1	60.5	113	5	80-120	20

Figure 4: TYPICAL CASE NARRATIVE

CASE NARRATIVE

Client : XYZ, INC.

Project : CLEAN PROJECT

SDG : 10K283

METHOD 6020A
METALS BY ICP-MS

A total of twelve (12) soil samples were received on 11/19/10 for Total Metals by ICP-MS analysis, Method 6020A in accordance with USEPA SW-846, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods.

Holding Time
Samples were analyzed within the prescribed holding time.

Calibration
Initial Calibration was established as prescribed by the method and was verified using a secondary source. Interference checks were performed and results were within required limits. Continuing calibration verifications and continuing calibration blanks were carried out at the frequency specified by the project. All calibration requirements were within acceptance criteria.

Method Blank
Method blank was analyzed at the frequency required by the project. For this SDG, one method blank was analyzed with the samples. Result was compliant to project requirement.

Lab Control Sample
A set of LCS/LCD was analyzed with the samples in this SDG.
Percent recoveries for IMK029SL/C were all within QC limits.

Matrix QC Sample
Matrix QC sample was analyzed at the frequency prescribed by the project.
Percent recoveries were within project QC limits except for results qualified with [*] in K283-10M/S summary form, most likely due to matrix interference.
Check QC summaries form for details.
In addition Analytical spike and serial dilution were analyzed for matrix interference evaluation. Results were within method acceptance criteria.

Sample Analysis
Samples were analyzed according to prescribed analytical procedures. All project requirements were met otherwise anomalies were discussed within the associated QC parameter.

Appendix 1: SUMMARY OF QUALITY CONTROL PROCEDURES

QC PROCEDURES	FREQUENCY	ACCEPTANCE CRITERIA	CORRECTIVE ACTION	1st Rvw	2nd Rvw
Tune Check (Mass calibration and resolution check)	Daily before ICAL.	±0.10 AMU (Mass of Isotope) <0.9 AMU full width resolution RSD of 4 replicates : ≤5%	Correct problem and repeat tune check.		
Initial Calibration (multi-point)	Daily initial calibration prior to sample analysis.	r ≥ 0.998	Correct the problem and repeat the initial calibration.		
Initial Calibration Verifications (ICV) Second Source	Daily after the initial calibration.	All analytes within ±10% of expected value RSD of Replicate integrations: < 5%	Correct the problem and repeat the initial calibration.		
Low Level Calibration Verification (LLICV / LLCCV)	LLICV: Daily after initial calibration. LLCCV: At the end of the analysis sequence	All analytes with ± 30% of expected value.	Correct the problem and repeat the initial calibration.		
Calibration Verifications (CCV)	Daily before sample analysis, after every 10 samples and at the end of the analysis sequence.	All analytes within ±10% of expected value. RSD of replicate integrations < 5%.	Repeat calibration and reanalyze all samples since last successful calibration.		
Calibration Blanks (ICB/CCB)	After every calibration verification	All target analytes < LOQ.	Correct problem then reanalyze calibration blank and previous samples.		
Interference Check Sample (ICSA/ICSAB)	Analyze at the beginning of each analytical run or once every 12 hours , whichever is more frequent.	Within ±20% of expected value	Terminate analysis, correct the problem, reanalyze ICS, and reanalyze all affected samples		
Internal Standard (IS)	ICV, LLICV, CCV, LLCCV, CCBs, MB, LCS, every sample	IS Intensities > 70% from Initial Calibration Blank IS Intensity	Correct problem then re-analyze		
Method Blank	One per preparation batch	All target analytes < ½ LOQ.	Re-digest and reanalyze method blank and all samples processed with the contaminated blank.		
Laboratory Control Sample (LCS)	One per preparation batch	% Recovery: 80% - 120%	Re-digest and reanalyze LCS and all associated samples		
Matrix Spikes (MS/MSD)	One MS/MSD every 20 project samples per matrix	% Recovery: 75% - 125% RPD ≤20%	Evaluate post spike and dilution test: • If parent sample result is "ND", evaluate post spike. • If parent sample result is high (i.e., 4x of spike concentration) and post spike failed, evaluate dilution test.		
Post Digestion Spike Addition	When MS fails.	Recovery within 80-120% of expected value	Correct the problem then reanalyze post digestion spike addition		
Dilution Test (5X)	When MS fails.	1:5 dilution must agree within ±10% of the original determination	Evaluate. Discuss in case narrative.		
Instrument Detection Limit (IDL)	Every three months		Correct the problem and repeat the IDL determination.		
Comments: Refer to PSR for flagging criteria.			Reviewed By:		
			Date:		

Appendix 2: DEMONSTRATION OF CAPABILITY

DEMONSTRATION OF CAPABILITY
METHOD: SW 6020A

SOP: EMAX-6020
Conc Unit: µg/L
Sample Amt(ml): 50

Instrument ID: I98
Analysis date: 1/7/2011
Analyzed by: C. Capulong

MATRIX : WATER

PARAMETER	98A04019	98A04020	98A04021	98A04022	TV	Ave. Conc.	Ave. %Rec	SD	RSD (%)	QC Criteria	COMMENTS
	IMA006WL	IMA006WC	IMA006WX	IMA006WY							
Aluminum	2513	2514	2516	2513	2500	2514	101	1.41	0.06	80 - 120	PASSED
Antimony	25.1	25.1	25.2	25.0	25	25	100	0.09	0.36	80 - 120	PASSED
Arsenic	24.6	25.0	24.8	24.8	25	25	99	0.17	0.67	80 - 120	PASSED
Barium	25.7	25.6	25.7	25.4	25	26	102	0.15	0.58	80 - 120	PASSED
Beryllium	26.2	26.4	26.0	26.4	25	26	105	0.18	0.67	80 - 120	PASSED
Boron	27.3	27.8	27.2	27.7	25	28	110	0.31	1.13	80 - 120	PASSED
Cadmium	25.4	25.3	25.5	25.2	25	25	101	0.13	0.50	80 - 120	PASSED
Calcium	2578	2555	2563	2585	2500	2570	103	13.70	0.53	80 - 120	PASSED
Chromium	25.4	25.4	25.3	25.0	25	25	101	0.18	0.72	80 - 120	PASSED
Cobalt	25.4	26.0	25.6	25.6	25	26	103	0.22	0.87	80 - 120	PASSED
Copper	25.6	25.8	25.7	25.3	25	26	102	0.22	0.86	80 - 120	PASSED
Iron	2600	2583	2596	2594	2500	2593	104	7.27	0.28	80 - 120	PASSED
Lead	25.7	25.8	25.5	25.6	25	26	103	0.10	0.40	80 - 120	PASSED
Lithium	24.6	24.9	24.7	25.1	25	25	99	0.22	0.88	80 - 120	PASSED
Magnesium	2510	2516	2492	2506	2500	2506	100	10.20	0.41	80 - 120	PASSED
Manganese	25.6	25.7	25.7	25.4	25	26	102	0.15	0.59	80 - 120	PASSED
Molybdenum	25.1	25.1	25.1	24.7	25	25	100	0.19	0.74	80 - 120	PASSED
Nickel	25.3	25.6	25.4	25.0	25	25	101	0.23	0.91	80 - 120	PASSED
Potassium	2602	2593	2602	2558	2500	2589	104	20.93	0.81	80 - 120	PASSED
Selenium	25.4	25.1	25.3	25.0	25	25	101	0.16	0.62	80 - 120	PASSED
Silver	25.4	25.6	25.5	25.0	25	25	101	0.27	1.05	80 - 120	PASSED
Sodium	2507	2502	2507	2544	2500	2515	101	19.48	0.77	80 - 120	PASSED
Strontium	25.3	25.4	25.3	25.2	25	25	101	0.09	0.35	80 - 120	PASSED
Thallium	25.5	25.9	25.7	25.7	25	26	103	0.16	0.63	80 - 120	PASSED
Tin	25.1	25.2	25.5	25.3	25	25	101	0.15	0.59	80 - 120	PASSED
Titanium	25.2	25.0	25.2	24.8	25	25	100	0.17	0.66	80 - 120	PASSED
Uranium	26.1	26.1	25.9	25.9	25	26	104	0.13	0.50	80 - 120	PASSED
Vanadium	25.3	25.4	25.2	24.8	25	25	101	0.26	1.03	80 - 120	PASSED
Zinc	25.3	25.4	25.6	25.2	25	25	101	0.15	0.59	80 - 120	PASSED

Appendix 2 (Cont.): DEMONSTRATION OF CAPABILITY

DEMONSTRATION OF CAPABILITY
METHOD: SW 6020A

Analytical SOP: EMAX-6020
Conc Unit: µg/L
Sample Amt(ml): 50

Analysis date: 5/9/2011
Extracted by: C. Capulong
Analyzed by: C. Capulong

PARAMETER	98E05041	98E05042	98E05043	98E05044	TV	Ave. Conc.	Ave. %Rec	SD	RSD (%)	QC Criteria	COMMENTS
	IME016WL	IME016WC	IME016WX	IME016WY							
Phosphorus	236.9	244.8	236.5	237.6	250	239	96	3.93	1.64	80 - 120	PASSED
Zirconium	25.0	27.2	25.8	26.3	25	26.1	104	0.93	3.55	80 - 120	PASSED

DEMONSTRATION OF CAPABILITY
METHOD: SW 6020A

SOP: EMAX-6020
Conc Unit: µg/L
Sample Amount(mL): 50

Instrument ID: 98
Analysis date: 6/25/2013
Analyzed by: C. Capulong

PARAMETER	98F06024	98F06025	98F06026	98F06027	TV	Ave. Conc.	Ave. %Rec	SD	RSD	QC Criteria	COMMENTS
	IMF012WL	IMF012WC	IMF012WX	IMF012WY							
Tungsten	26.8	26.7	26.4	26.6	25	26.3	105	0.15	0.6	80 - 120	PASSED

Appendix 2 (Cont.): DEMONSTRATION OF CAPABILITY

DEMONSTRATION OF CAPABILITY
METHOD: SW 6020A

SOP: EMAX-6020
Conc Unit: mg/Kg
Sample Amt(gm): 1

Instrument ID: I98
Analysis date: 1/7/2011
Analyzed by: C. Capulong

MATRIX : SOIL

PARAMETER	98A04027	98A04028	98A04029	98A04030	TV	Ave. Conc.	Ave. %Rec	SD	RSD (%)	QC Criteria	COMMENTS
	IMA007SL	IMA007SC	IMA007SX	IMA007SY							
Aluminum	2439	2397	2422	2435	2500	2423	97	18.95	0.78	80 - 120	PASSED
Antimony	21.1	20.9	20.8	20.8	25	21	84	0.13	0.61	80 - 120	PASSED
Arsenic	20.7	20.5	20.9	20.9	25	21	83	0.22	1.04	80 - 120	PASSED
Barium	21.6	21.5	21.4	21.7	25	22	86	0.12	0.54	80 - 120	PASSED
Beryllium	21.7	21.7	21.7	21.6	25	22	87	0.05	0.23	80 - 120	PASSED
Boron	23.0	23.2	23.4	23.5	25	23	93	0.23	1.00	80 - 120	PASSED
Cadmium	21.1	20.8	20.7	21.0	25	21	83	0.19	0.92	80 - 120	PASSED
Calcium	2535	2511	2502	2524	2500	2518	101	14.49	0.58	80 - 120	PASSED
Chromium	21.3	21.3	21.5	21.2	25	21	85	0.11	0.51	80 - 120	PASSED
Cobalt	21.5	21.2	21.6	21.5	25	21	86	0.20	0.95	80 - 120	PASSED
Copper	21.1	21.2	21.2	20.8	25	21	84	0.17	0.82	80 - 120	PASSED
Iron	2509	2501	2470	2525	2500	2501	100	23.10	0.92	80 - 120	PASSED
Lead	21.8	21.6	21.5	21.6	25	22	87	0.13	0.59	80 - 120	PASSED
Lithium	20.9	21.1	21.1	21.1	25	21	84	0.07	0.31	80 - 120	PASSED
Magnesium	2424	2401	2413	2427	2500	2416	97	11.81	0.49	80 - 120	PASSED
Manganese	21.5	21.5	21.6	21.5	25	22	86	0.06	0.29	80 - 120	PASSED
Molybdenum	21.4	21.2	21.3	21.4	25	21	85	0.11	0.53	80 - 120	PASSED
Nickel	20.9	20.8	21.0	20.8	25	21	83	0.08	0.36	80 - 120	PASSED
Potassium	2493	2499	2495	2483	2500	2493	100	6.81	0.27	80 - 120	PASSED
Selenium	21.1	20.8	21.3	21.1	25	21	84	0.19	0.92	80 - 120	PASSED
Silver	21.6	21.4	21.5	21.8	25	22	86	0.17	0.80	80 - 120	PASSED
Sodium	2440	2435	2390	2464	2500	2432	97	30.88	1.27	80 - 120	PASSED
Strontium	21.5	21.3	21.5	21.7	25	21	86	0.17	0.80	80 - 120	PASSED
Thallium	21.6	21.4	21.4	21.5	25	21	86	0.08	0.39	80 - 120	PASSED
Tin	24.6	24.2	24.1	24.3	25	24	97	0.24	1.00	80 - 120	PASSED
Titanium	21.6	21.4	21.5	21.5	25	22	86	0.08	0.38	80 - 120	PASSED
Uranium	22.4	22.0	22.4	22.4	25	22	89	0.21	0.96	80 - 120	PASSED
Vanadium	21.4	21.2	21.3	21.1	25	21	85	0.12	0.57	80 - 120	PASSED
Zinc	22.6	21.8	21.9	22.7	25	22	89	0.47	2.11	80 - 120	PASSED

Appendix 2 (Cont.): DEMONSTRATION OF CAPABILITY

DEMONSTRATION OF CAPABILITY
METHOD: SW 6020A

Analytical SOP: EMAX-6020
Conc Unit: mg/Kg
Sample Amt(ml): 1

Analysis date: 5/9/2011
Extracted by: C. Capulong
Analyzed by: C. Capulong

PARAMETER	98E05021	98E05022	98E05023	98E05024	TV	Ave. Conc.	Ave. %Rec	SD	RSD (%)	QC Criteria	COMMENTS
	IME012SL	IME012SC	IME012SX	IME012SY							
Phosphorus	257	255	255	252	250	255	102	2.25	0.88	80 - 120	PASSED
Zirconium	27.3	29.3	29.7	29.5	25	28.9	116	1.12	3.87	80 - 120	PASSED

DEMONSTRATION OF CAPABILITY
METHOD: SW 6020A

SOP: EMAX-6020
Conc Unit: mg/Kg
Sample Amount(g): 1

Instrument ID: 98
Analysis date: 6/25/2013
Analyzed by: C. Capulong

PARAMETER	98F06019	98F06020	98F06021	98F06022	TV	Ave. Conc.	Ave. %Rec	SD	RSD	QC Criteria	COMMENTS
	IMF014SL	IMF014SC	IMF014SX	IMF014SY							
Tungsten	25.8	25.9	26.1	26.1	25	25.8	103	0.15	0.6	80 - 120	PASSED

Appendix 3: COMPARATIVE STUDY OF MODIFIED 3050B

ANALYTICAL METHOD: SW 6020A
PREPARATION BATCH: IMG031S - Modified Method 3050B
IMG032S - Reference Method 3050B
ANALYTICAL BATCH: I98H01
QC STANDARD: 09G281-02

Preparation Date: 7/27/2010
Extracted by: M. Mendoza
Analytical Run Date: 8/3/2010
Analyzed by: C. Capulong

COMPOUND	TRUE VALUES (mg/Kg)	ACCEPTANCE LIMITS (mg/Kg)	RECOVERY LIMITS (%)	REFERENCE METHOD 3050B				MODIFIED METHOD 3050B			
				Concentration (mg/Kg)		Recovery		Concentration (mg/Kg)		Recovery	
				98H01041 G281-02	98H01043 G281-02D	98H01041 G281-02	98H01043 G281-02D	98H01030 G281-02	98H01032 G281-02D	98H01030 G281-02	98H01032 G281-02D
Aluminum	7320	4940 - 16400	67 - 224	10900	10700	149%	146%	10700	10700	146%	146%
Antimony	110	11.0 - 121	10 - 110	20.0	19	18%	17%	61.4	66.6	56%	61%
Arsenic	84.2	42.8 - 92.7	51 - 110	61.2	61.7	73%	73%	63.6	65.3	76%	78%
Barium	247	186 - 318	75 - 129	255	260	103%	105%	275	273	111%	111%
Beryllium	49.0	29.0 - 53.9	59 - 110	39.7	39.6	81%	81%	42	41.7	86%	85%
Boron	130	61.8 - 149	48 - 115	104	104	80%	80%	126	126	97%	97%
Cadmium	76.5	48.7 - 84.4	64 - 110	65.3	66.7	85%	87%	69.9	69.8	91%	91%
Calcium	10200	7860 - 12900	77 - 126	9360	10700	92%	105%	10200	10300	100%	101%
Chromium	116	74.8 - 140	64 - 121	99.5	98.4	86%	85%	107	110	92%	95%
Cobalt	64.6	47.2 - 79.7	73 - 123	62.1	61.3	96%	95%	63.8	64	99%	99%
Copper	143	99.7 - 166	70 - 116	116	115	81%	80%	127	126	89%	88%
Iron	23300	11500 - 36200	49 - 155	23900	23700	103%	102%	24800	24800	106%	106%
Lead	82.0	41.9 - 90.2	51 - 110	63.3	64.9	77%	79%	67.5	67.6	82%	82%
Magnesium	7400	5300 - 9060	72 - 122	6770	6760	91%	91%	6930	7100	94%	96%
Manganese	475	428 - 724	90 - 152	546	562	115%	118%	584	571	123%	120%
Molybdenum	66.1	36.0 - 72.7	54 - 110	54.9	53.5	83%	81%	60.1	59.4	91%	90%
Nickel	144	88.8 - 158	62 - 110	112	113	78%	78%	122	122	85%	85%
Potassium	3740	2360 - 4990	63 - 133	3620	3600	97%	96%	3690	3560	99%	95%
Selenium	189	97.2 - 208	51 - 110	142	148	75%	78%	154	157	81%	83%
Silver	40.6	21.2 - 44.6	52 - 110	30.9	32.7	76%	81%	34.2	34.9	84%	86%
Sodium	200	31.4 - 324	16 - 162	292	197	146%	99%	192	200	96%	100%
Strontium	135	88.1 - 162	65 - 120	123	121	91%	90%	129	128	96%	95%
Thallium	127	73.2 - 144	58 - 113	110	114	87%	90%	117	112	92%	88%
Tin	250	39.5 - 275	16 - 110	71.2	73.2	28%	29%	84.7	85.2	34%	34%
Titanium	609	426 - 792	70 - 130	737	744	121%	122%	772	760	127%	125%
Uranium	1.12	0.784 - 1.46	70 - 130	0.93	1.1	83%	98%	1.03	1.01	92%	90%
Vanadium	61.8	55.6 - 123	90 - 199	90.2	89.7	146%	145%	92.8	93.1	150%	151%
Zinc	208	145 - 270	70 - 130	208	207	100%	100%	225	214	108%	103%

** Note: Modified 3050B procedure is specified in EMAX-3050 Rev. 4*

6020FS: SAMPLE PREPARATION LOG

EMAX LABORATORIES, INC.

DIGESTION LOG
for
ICP-MS

Page 1

Note: For samples, relevant QCs/Standards digested, refer to attached digestion sequence.

Comments:

Book #: EIM-033
Batch:
Matrix:
Digestor ID:

SOP #	Rev. #
☐ EMAX-200.8	
☐ EMAX-6020	
☐ EMAX-	

Start	Temp	End	Temp
	°C		°C

Standards	ID	Amount Added (ml)
LCS-1		
LCS-2		
MS		
Reagent	**Lot# / ID**	**Amount Added (ml)**
HNO_3		
HCl		
H_2O_2		
HNO3(1:1)		

Digestate Location	
Extract Location	

☐ Soil Samples: -diluted 1 ml of digestate to 10 ml reagent water (DF=100)

☐ Reagent Water ID:

☐ Thermometer ID:

☐ Pipette ID:

☐ Pipette ID:

☐ Pipette ID:

☐ HNO_3 dispenser checked @ 5.0 ml with Class A volumetric flask

☐ HCl dispenser checked @ 5.0 ml with Class A volumetric flask

Prepared By:

Standard Added By: Witnessed By:

Extract Rcvd By: Checked By:

6020FA: ANALYSIS RUN LOG

EMAX LABORATORIES, INC.

ANALYSIS RUN LOG
for
ICP-MS

Page 1

Note: For samples and relevant QCs/Standards analyzed, refer to attached analytical sequence.

Start Date:

End Date:

Comments:

Book #: A98-030

Instrument No.: 98

Analytical Batch:

Analytical Sequence:

Method File:

SOP #	Rev. #
☐ EMAX-6020	
☐ EMAX-200.8	
☐ EMAX-	

STANDARDS ID	
S0	
S1	
S2	
S3	
S4	
S5	
S6	
S7	
ICV	
CCV	
ICSA	
ICSAB	
6020 TUNE SOLN.	
200.8 TUNE SOLN.	
MRL1	
MRL2	
MRL3	

Analyzed By:

Date:

6020FM: INSTRUMENT MAINTENANCE LOG

EMAX LABORATORIES, INC.

Page 1

ICP-MS MAINTENANCE LOG

Instrument No: 98 Month: Year: 201_ Book # M98-007

Date							
Argon, Hydrogen, Helium							
Instrument Discharge							
Pump Tubings							
Rinse Bottle							
Printer Paper							
Autosampler							
Cooling Water							
Peri Pump Rate (0.08-0.12 RPS)							
Nebulizer Gas (0.8-1.30 L/min)							
Makeup Gas (0.1-0.3 L/min)							
ICP-MS TUNE							
Li - 7 (≥ 6400 Counts)							
Y - 89 (≥ 16000 Counts)							
Tl - 205 (≥ 9600 Counts)							
Oxides (MO^+) ≤ 2%							
Double Charge (M^{++}) ≤ 2%							
Analyst Initials							
ICP-MS TUNE							
Problem(s) Encountered							
Corrective Action							
Return To Specs (Analyst Initials)							

Code	Problems Encountered	Code	Corrective Action

STANDARD OPERATING PROCEDURES

MERCURY IN LIQUID WASTE

SOP No.:	EMAX-7470	Revision No.	7	Effective Date:	12-Dec-12
Prepared By:	Mary Jane Mendoza			Date:	12.11.12
Approved By:	Kenette Pimentel QA Manager			Date:	12.11.12
Approved By:	Caspar Pang Laboratory Director			Date:	12-11-12

Control Number: 7470-07-

1.0 SCOPE AND APPLICATION

1.1. This procedure applies to the measurement of Mercury in aqueous wastes, leachates, and wastewater samples by Cold Vapor Absorption Technique.

1.2. This SOP is an adaptation of SW846 Methods 7470A.

2.0 SUMMARY OF METHOD

2.1. A representative amount of sample is digested in nitric and sulfuric acids, followed by oxidation with potassium permanganate and potassium persulfate.

2.2. Organic mercurial are broken down and converted into mercuric ions in order to respond to the cold vapor atomic absorption technique. Persulfate oxidation step, followed by addition of permanganate ensures that organo-mercury compounds are oxidized.

2.3. Absorption of radiation by mercury vapor at 253.7 nm is then measured in the digested samples.

2.4. **Interferences**

2.4.1. Sulfides, as sodium sulfide, Copper and Chloride at high concentrations are known to interfere with the recovery of mercury. Samples containing such interference may require additional permanganate (about 12.5 ml).

2.4.2. Care must be taken to ensure that free chlorine is absent before the mercury is swept into the cell. This may be accomplished by using an excess of hydroxylamine hydrochloride reagent.

2.4.3. Certain volatile organic materials that absorb at this wavelength may also cause interference. A preliminary run without reagents should determine if this type of interference is present.

3.0 DETECTION LIMITS

3.1. **Detection Limit (DL), Limit of Detection (LOD) and Limit of Quantitation (LOQ)**

3.1.1. Refer to EMAX-QA04 for generation, validation and verification of DL, LOD and LOQ.

3.2. **Established DL, LOD & LOQ**

PARAMETER	DL	LOD	LOQ	Unit
Water	0.054	0.1	0.50	µg/L

4.0 DYNAMIC RANGE

4.1. The highest quantifiable range requiring no dilution is equal to the concentration of the highest calibration point (see Section 9.6). All samples analyzed above this range are considered "over range" and requires dilution to properly quantitate.

4.2. The lowest quantifiable range of diluted samples is equal to the concentration of the lowest calibration point. All diluted samples analyzed below this range are considered as "under range" and requires lower dilution factor to properly quantitate.

5.0 SAMPLE HOLDING TIME AND PRESERVATION

5.1. **Sample Collection**

5.1.1. Samples are expected to be contained in HDPE pre-cleaned containers and preserved with HNO3 to pH < 2 and cooled to ≤ 6°C without freezing.

5.2. **Holding Time**

5.2.1. Samples must be analyzed within 28 days from date of collection.

5.3. **Preservation**

5.3.1. Store samples and extracts at ≤ 6°C without freezing.

6.0 ASSOCIATED SOPs

6.1.	EMAX-DM01	Data Flow and Review
6.2.	EMAX-QA04	Detection Limit (DL)
6.3.	EMAX-QA05	Training
6.4.	EMAX-QA08	Corrective Action
6.5.	EMAX-QC01	Quality Control of Chemicals
6.6.	EMAX-QC02	Analytical Standard Preparation
6.7.	EMAX-QC06	Calibration of Micropipettes
6.8.	EMAX-QC07	Glassware Cleaning
6.9.	EMAX-SM03	Waste Disposal
6.10.	EMAX-SM04	Analytical and QC Sample Labeling

7.0 SAFETY

7.1. Read all MSDS of chemicals listed in this SOP.

7.2. Treat reagents, standards, and samples as potential hazards. Observe the standard laboratory safety procedures. Wear protective gear, i.e., lab coat, safety glasses, and gloves at all times when performing this procedure. Perform preparation and analysis of mercury in a fume hood equipped with an exhaust fan or blower.

7.3. If for any reason, sample and/or other reagents get in contact with your skin or any other part of your body, rinse the affected body part thoroughly with copious amounts of water. If irritations persist inform your supervisor immediately so that proper action can be taken.

7.4. Do not look directly at the Mercury Lamp while lit. The radiation may cause damage to your eyes.

7.5. Perform all reagent additions under a fume hood.

7.6. Mercury Analyzers are to be used by trained personnel only.

8.0 INSTRUMENTS, CHEMICALS AND REAGENTS

8.1. Instruments and Supplies

8.1.1. Mercury Analyzers

8.1.1.1. Leeman PS-200 Automated Mercury Analyzer with Autosampler, Computer, Printer and PS 200 Software

8.1.1.2. Leeman Hydra AA Automated Analyzer with Autosampler, Computer, Printer and PS200 Software

8.1.2. 100 ml Digestion vessel

8.1.3. Digestate containers

8.1.4. Digestion block or equivalent

8.1.5. Magnetic stirrer

8.1.6. Micropipettes and tips

8.1.7. Thermometer

8.2. Chemicals and Reagents

8.2.1. Where available, purchase reagent grade chemicals and reagents

8.2.2. Sulfuric Acid, concentrated

8.2.3. Nitric Acid, concentrated

8.2.4. Hydroxylamine hydrochloride: Dissolve 120 g of hydroxylamine hydrochloride in reagent water and dilute to 1 L.

8.2.5. Potassium Permanganate, 5% solution: Dissolve 50 g of potassium permanganate in 1 L reagent water.

8.2.6. Potassium Persulfate, 5% solution: Dissolve 50 g of potassium persulfate in 1 L reagent water.

8.2.7. Stannous Chloride – 10% solution: Dissolve 200 g of $SnCl_2$ in reagent water, add 200 ml HCl and volume to 2 L.

8.2.8. Reagent Water – Mercury-free water

9.0 STANDARDS

9.1. Refer to EMAX-QC02 for proper analytical standard preparations.

9.2. Other concentration levels may be prepared to meet the data quality objective of a project.

9.3. **Stock Standard**

9.3.1. Purchase stock standards as certified solutions from two different vendors. Use one as primary standard and the other as secondary standard.

9.3.2. Transfer standards on a properly labeled inert vial with minimal headspace and store it at -10°C to -20°C.

9.3.3. Prepare calibration standards from the primary standard.

9.3.4. Prepare initial calibration verification standards and spiking standards from the secondary standard.

Stock Std	Name	Source	CAT #	CONC	NOTES
Primary/CCV	Mercury	Leeman	602-00064	100 mg/L	Or equivalent
ICV /LCS/MS	Mercury	ERA	027	1000 mg/L	Or equivalent

9.4. **Intermediate Standard Solution**

9.4.1. From 100 µg/L stock solution take a 2 ml aliquot and dilute to 200 ml using reagent water. The solution shall have a final concentration of 1.0 mg/L.

9.4.2. Prepare secondary dilution from 1000 mg/L stock solution take a 1 ml aliquot and dilute to 100 ml using reagent water. This solution shall have a final concentration of 10 mg/L.

9.5. **Working Standard**

9.5.1. From the secondary dilution of intermediate standard prepare the working standard solution to have a final concentration of 50 µg/L.

9.6. **Initial Calibration Standards**

9.6.1. From the working solution prepare the following *Leeman* standards in 100 ml volumetric flasks.

Level	Aliquot (ml)	Final Volume (ml)	Concentration (µg/L)
S0	0	50	0
S1	0.2	50	0.2
S2	1.0	50	1.0
S3	2.0	50	2.0
S4	5.0	50	5.0
S5	10.0	50	10.0
CCV	5.0	50	5.0

9.7. **ICV/CCV/LCS/MS**

9.7.1. From the working standard, prepare ICV/CCV/LCS/MS solutions using *ERA* Standards.

Name	Aliquot (ml)	Final Volume (ml)	Concentration (µg/L)
ICV	2.0	50	2.0
LCS/MS	5.0	50	5.0

10.0 PROCEDURES

10.1. Sample Preparation

10.1.1. Transfer 50 ml of sample into 100 ml digestion vessel. Use reagent water for method blank, LCS, and calibration standards. For STLC and TCLP extracts, use 5 ml sample volume diluted with reagent water to 50 ml. (The reduction of the volume is due to waste minimization.)

10.1.2. Add spike standards to LCS/MS. Add appropriate standards for calibration standards. Subsequently perform the following steps for each of the prepared analytical samples.

10.1.3. Add 2.5 ml of concentrated H_2SO_4 and 1.25 ml concentrated HNO_3 with mixing after each addition.

10.1.4. Add 7.5 ml of 5% $KMnO_4$ solution to each vessel.

10.1.5. Swirl each vessel to mix and let it stand by for 15 min. Check each vessel if purple color persist. If not, add permanganate solution at 2.5 ml increments swirling the Digestion vessel at every addition, until purple color persists.

Add the maximum amount of permanganate solution added to a sample, to the method blank, LCS, calibration standards and calibration verification standards.

10.1.6. Add 4 ml of 5% potassium persulfate. Heat for 2 hours in hot block maintained at 95°C.

10.1.7. Allow the samples to cool.

10.1.8. Add 3 ml hydroxylamine hydrochloride solution and dilute to 80 ml using reagent water. Proceed to 10.2.

10.1.9. Properly fill up the sample preparation log.

10.2. Instrument Parameters

10.2.1. PROTOCOL

10.2.1.1. Set Values

Instrument ID:	PS200	HYDRA AA
Number of Integration	1	
Uptake time	20 sec.	18 sec.
Weight	N	N
Dilution	N	N
On/Off, times, gains		
On	Y	Y

Time	10	10
Instrument ID:	PS200	HYDRA AA
Gas	0.35 LPM	0.15 LPM
Pump Rate	5 ml/min	7 ml/min
AUTOSAMPLER – Setup		
Station 1 (rack1)	From cup 1 to cup 44	From cup 1 to cup 44
Station 2 (rack 2)	From cup 1 to cup 44	From cup 1 to cup 44
Rinse time	60 sec.	60 sec.

CALIBRATION S0, S1, S2, S3, S4, S5	Concentration, µg/L 0.0,0.2, 1.0, 2.0, 5.0, 10.0	Concentration, µg/L 0 0,.20, 1.0, 2.0, 5.0, 10.0

10.2.2. DATA OUTPUT – Specify Report

Data Output	Real Time	Post Run
Samples	Y	Y
Standards	Y	Y
Updates	Y	Y
Peaks	N	N
IEC Stds.	N	N
Check Stds.	Y	Y
Dups and % Diff.	Y	Y
Wavelength	N	N
Rel. Absorbances	N	N
% RSD	Y	Y
Scans to PRN		N
Detail		Y
Summary		N
Post Run Copies		1
Post Run Report Order [1-sorted; 2- sequential]	2	

10.3. **Calibration**

10.3.1. Instrument Set-up

10.3.1.1. Set up PS200 or Hydra AA to proper operating parameters. Refer to Section 10.2.1.

New pump tubing, must be ran with rinse for 45 minutes to break in the tubing.

10.3.1.2. Turn on the lamp and allow to warm up for at least 5 minutes.

10.3.1.3. Check the peristaltic pump to deliver a steady flow.

10.3.1.4. Check that the reductant solution, 10% $SnCl_2$, is sufficient. If not, prepare solution as described in Section 8.2.7.

10.3.2. Initial Calibration (ICAL)

10.3.2.1. Prepare initial calibration solution as described in Section 9.6.1.

10.3.2.2. Perform the same procedural steps used for analytical samples as described in Section 10.1.

10.3.2.3. Analyze them as described in Section 10.4.

10.3.2.4. Refer to Section 10.5 for calculation.

10.3.2.5. Initiate initial calibration as described in the instrument operations manual and acquire the calibration data for review after calibration is completed.

10.3.2.6. Refer to Appendix 1 for acceptance criteria.

10.3.2.7. Verify the initial calibration by a secondary source standard.

10.3.3. Initial Calibration Verification (ICV)

10.3.3.1. Prepare ICV as described in Section 9.7.1.

10.3.3.2. Perform the same procedural steps used for analytical samples as described in Section 10.1.

10.3.3.3. Analyze the ICV sample to verify the concentration of the ICAL.

10.3.3.4. Refer to Appendix 1 for acceptance criteria.

10.3.4. Continuing Calibration Verification (CCV)

10.3.4.1. Prepare CCV as described in Section 9.6.1.

10.3.4.2. Perform the same procedural steps used for analytical samples as described in Section 10.1.

10.3.4.3. Analyze CCV sample to verify the validity of ICAL.

10.3.4.4. Refer to Appendix 1 for acceptance criteria.

10.4. **Analysis**

10.4.1. Analytical Sequence

10.4.1.1. From the main menu, select Autosampler and the set-up.

10.4.1.1.1. Type the rack number to be ran (1 or 2) and type the rack name and press ENTER. SET UP screen for that rack will appear and a BEGIN CUP prompt will be displayed at the bottom of the screen.

10.4.1.1.2. Enter the number (CUP POSITION) of the first cup to be sampled and press ENTER. An END CUP prompt will now be displayed at the bottom of the screen.

10.4.1.1.3. Enter the number of the last cup to be sampled and press ENTER. If second rack is to be used, repeat Steps 10.4.1.1.1. to 10.4.1.1.3.

10.4.1.2. Typical Analytical Sequence

10.4.1.2.1. ICV

10.4.1.2.2. ICB

10.4.1.2.3. CCV1

10.4.1.2.4. CCB1

10.4.1.2.5. Method Blank

10.4.1.2.6. LCS

10.4.1.2.7. LCSD

10.4.1.2.8. Post Analytical Spike

10.4.1.2.9. Parent Sample

10.4.1.2.10. Serial Dilution

10.4.1.2.11. MS

10.4.1.2.12. MSD

10.4.1.2.13. Maximum of 2 samples

10.4.1.2.14. CCV2

10.4.1.2.15. CCB2

10.4.1.2.16. Maximum of 10 samples

10.4.1.2.17. CCV3

10.4.1.2.18. CCB3

10.4.1.3. Using the analytical sequence, arrange the digested standards and samples to be analyzed chronologically.

10.4.1.4. Transfer about 6 ml of the digestates into the autosampler tubes placing them on the autosampler rack in the same order as the analytical sequence.

10.4.1.5. Prepare a Dilution Test sample at 5 times dilution. Pipette 2 ml of sample, add 8 ml of S0 into a sample tube. Seal the tube with parafilm and invert the tube several times to ensure adequate mixing.

10.4.1.6. Prepare a Post Digestion Spike test sample. Using the un-spiked sample digestate (preferably the QC sample), add MS standard to maintain the same spike level as the MS digestate.

10.4.1.7. Set the prepared samples into the autosampler and start the analytical run.

10.4.2. Sample Result Evaluation

10.4.2.1. Check QC criteria as soon as data is available.

10.4.2.1.1. Check the LCS recoveries against project specific requirement (PSR). In the absence of PSR, default to Appendix 1 for QC limits.

10.4.2.1.2. Check the MS, serial dilution and post-digestion spike[1] recovery against project specific requirement (PSR). In the absence of PSR, default to Appendix 1 for QC limits.

10.4.2.1.3. Check sample result concentrations are within the calibration range.

10.4.2.2. Check the sample analyzed after a sample having target analyte concentrations exceeding the calibration range.

10.4.2.2.1. If there is no target analyte detected as found in the sample that exceeded the calibration range, proceed with data reduction.

10.4.2.2.2. If there is any target analyte detected as found in the sample that exceeded the calibration range, re-analyze the sample to rule-out carryover. If carryover is confirmed, proceed with data reduction and report the data from re-analysis.

10.4.2.3. Properly fill up the analytical run log.

10.4.2.4. Upload the electronic data to the network.

10.4.3. Method of Standard Addition (MSA)

10.4.3.1. Perform MSA for all EP extracts, samples for de-listing petition, whenever a new matrix is encountered and/or as indicated above.

10.4.3.2. Prepare three sample solutions (Ms1, Ms2, Ms3) to objectively produce equal increments of concentration in the final solution without diluting the sample more than 50% of its original volume and expected concentrations falls within the linear range.

Example: Sample concentration is tentatively determined at 2 µg/L.

Ms1 – take 10 ml of digestate and add 0.2 ml of 100 µg/L spike standard (≈ 6 µg/L)

Ms2 – take 10 ml of digestate and add 0.4 ml of 100 µg/L spike standard (≈ 7 µg/L)

Ms 3 – take 10 ml of digestate and add 0.6 ml of 100 µg/L spike standard (≈ 8 µg/L)

10.4.3.3. Analyze Ms1, Ms2 and Ms3 and calculate the results using Eq.-10.5.7.

10.5. **Calculations**

10.5.1. Calibration Factor

$$CF = \frac{R_a}{C_a} \qquad \text{Eq.-10.5.1}$$

where:

[1] This SOP defaults to Post-Digestion Spike recovery of 85-115% based on Method 7000A. However, if project specific requirements reference to Method 7000B, recovery requirement is 80 – 120%.

CF – Calibration factor

R_a – Response for analyte measured in absorbance

C_a – Known concentration of analyte measured in µg/L

10.5.2. Average Calibration Factor

$$ACF = \frac{\sum CF}{n} \qquad \text{Eq.-10.5.2}$$

where:

ACF – Average calibration factor

$\sum CF$ – Sum of calibration factors

n – Number of measurements

10.5.3. Correlation Coefficient

$$r(x,y) = \frac{\frac{1}{N}\sum_{i=1}^{N}(x_i - \bar{x})(y_i - \bar{y})}{(SD_x)(SD_y)} \qquad \text{Eq.-10.5.3}$$

where:

$r(x,y)$ – Correlation coefficient

N – Number of measurements

x_i – Found value of the ith measurement

$\bar{x}$ – Mean of found values

y_i – True value of the ith measurement

$\bar{y}$ – Mean of true values

SD_x – Standard deviation of the found values

SD_y – Standard deviation of the true values

10.5.4. Sample Result

$$C = (Rs)(CF)(DF)\frac{V_e}{S_a} \qquad \text{Eq.-10.5.4}$$

where:

C – Sample concentration in µg/L

CF – Calibration factor

DF – Dilution factor

R_s – Sample absorbance

V_e – Extract volume in L

S_a – Sample amount (ml)

10.5.5. Calculate for Percent Recovery

$$\%\,\mathrm{Recovery} = \frac{(C_f - C)}{C_s} \times 100 \qquad \text{Eq.-10.5.5}$$

where:

C_f – Concentration found

C – Concentration of the sample (use 0 for LCS)

C_s – Concentration of spike

10.5.6. Calculate for Relative Percent Difference

$$RPD = \frac{|C_1 - C_2|}{\left(\frac{C_1 + C_2}{2}\right)} \times 100 \qquad \text{Eq.-10.5.6}$$

where:

RPD – Relative Percent Difference

C_1 – Measured concentration of the first sample aliquot

C_2 – Measured concentration of the second sample aliquot

10.5.7. Calculation for MSA

$$C_x = \frac{(S_2)(V_s)(C_s)}{(S_2 - S_1)V_x} \qquad \text{Eq.-10.5.7}$$

where:

C_x – Concentration of the sample

C_s – Concentration of spike

S_1 – Analytical signal of MS1

S_2 – Analytical signal of MS2

V_x – Volume of sample aliquot

V_s – Volume of spike or reagent water

10.6. **Data Reduction**

10.6.1. Make a copy of the analytical run and sample preparation log.

10.6.2. Print a copy of raw data and the QC report.

10.6.3. Highlight the data to be reported.

10.6.4. Collate the reportable data separating the QC results from the sample results.

10.6.5. Keep all other data generated with the analytical folder marked with "For record only".

10.7. **Report Generation**

10.7.1. Generate the report using the following in-house reporting program:

Executable Files	Required Support Files	Output
WDB5.exe	Login File (requires network), project.pln, seq_name.hg	Method.txt [this file integrates the login sample information and the analytical sample information]
MSRB6.exe	method.txt, method.met, method.crf, project.pln, project code.txt, qcell.txt	Sample Results (Form1)
IQCV3C.exe	method.txt, method.crf, method.qc, project.pln, project code.txt, qcell.txt	QC Summary for LCS, MS, Post Digestion Spike (Form 3)
CQ1.exe	method.txt, method.crf, method.qc, project.pln, project code.txt, qcell.txt	Summary for Dilution Test, Sample Duplicate (Form 3)
LABCHRN1.exe	method.txt	Lab Chronicle
CN2.exe	method.txt, Form 1	Case Narrative

10.8. **Data Review**

10.8.1. Arrange the analysis package in sequence as detailed below.

10.8.1.1. Case Narrative

10.8.1.2. Lab Chronicle

10.8.1.3. Sample Results

10.8.1.4. LCS/LCSD Summary

10.8.1.5. MS/MSD Summary

10.8.1.6. Post Digestion Spike Summary

10.8.1.7. Dilution Test Result Summary

10.8.1.8. Analytical Run Log

10.8.1.9. Raw Data

10.8.1.10. Sample Preparation Log

10.8.1.11. Non-Conformance Report (if any)

10.8.2. Perform a 100% data review in accordance to EMAX-DM01 and the PSR.

- ✓ Check method blank is compliant to Project Specific Requirements (PSR) criteria.

- ✓ Check LCS/LCSD, MS/MSD and Dilution test against QC limits.
- ✓ Check analytical spike test if dilution test failed.
- ✓ Check for possible carry-over and if confirmation is performed.
- ✓ Review the attached logs that they are properly filled.
- ✓ Check the generated reports against the raw data, analytical run log and sample preparation log. Check that the analytical data generated indicating positive results are qualitatively and quantitatively correct.
- ✓ Review the case narrative and check that it accurately describes what transpired in the analytical process. Edit as necessary to reflect essential issues not captured by the case narrative generator program.

10.8.3. Submit the analytical folder for secondary review

10.9. **Preventive Maintenance**

10.9.1. Daily routine maintenance must be observed religiously. Observe manufacturer's notes regarding DOs and DON'Ts:

- System preparation is a ***MUST*** before instrument startup.
- Make certain that drying tube has been packed loosely. If drying tube is blocked, liquid may backflow into the optical cell; this will require disassembly and leaning.
- Do not shutdown the instrument when operational, abort the run first if interruption is needed.

10.9.2. Daily routine maintenance including checking of reductant solution, 10% $SnCl_2$, trouble shooting and major repairs must be recorded in the maintenance log.

10.9.3. Maintain the instrument clean at all times.

10.9.4. For trouble shooting, consult the Operations Manual, Section 4.

11.0 QUALITY CONTROL

11.1. **Sample Preparation QC**

11.1.1. Pipettes must be calibrated prior to its use. Refer to EMAX-QC06 for details.

11.1.2. Reagents are subjected to QC check prior to its use. Refer to EMAX-QC01 for details.

11.1.3. A preparative batch consists of 20 or fewer samples of the same matrix, that are prepared for analysis simultaneously or sequentially, using the same lots of all reagents.

11.1.4. Every preparative batch must have at least one method blank, one LCS and a set of MS/MSD unless otherwise specified by the project. Digest QC samples together with the field samples.

11.1.5. Properly treat all lab wares used in the sample preparations as specified in EMAX-QC07.

11.2. **Sample Analysis QC**

11.2.1. Every analytical run is preceded with an Initial Calibration (ICAL) and Initial Calibration Verification (ICV). The ICV standard is obtained from a different source from that of the initial calibration.

Analyze an instrument calibration blank (ICB) after the ICV. No further analysis is valid unless acceptance criteria are met.

11.2.2. Verify calibration with Continuing Calibration Verification (CCV) standard and Continuing Calibration Blank (CCB) after every ten samples and at the end of the analytical run.

11.2.2.1. Perform Dilution Test whenever a new or unusual sample matrix is encountered.

11.2.2.2. Evaluate Post Digestion Spike result if the dilution test failed to meet the acceptance criteria.

11.2.3. Use Method of Standard Addition (MSA) technique for analysis of all EP extracts and whenever a new sample matrix is being analyzed.

11.2.4. Acceptance criteria, is summarized in Appendix 1.

11.3. **Method QC**

11.3.1. Perform dynamic range study at least every six months or whenever there is a significant change in instrument response. The analytically determined concentration of this standard must be within 10% of the expected value.

11.3.2. A valid DL and LOD must exist prior to sample analysis. Refer to EMAX-QA04 for details.

11.3.3. All analysts conducting this analysis must have an established Demonstration of Capability (DOC) as described in EMAX-QA05.

12.0 CORRECTIVE ACTION

12.1. Corrective actions for each Quality Control Procedure is summarized in Appendix 1.

12.2. **Calibration**

12.2.1. Initial Calibration (ICAL) - if ICAL is non-compliant, consider the following suggestions to correct the problem:

- Replace the sample tubing, prepare fresh rinsate and re-prepare fresh $SnCl_2$. Rinse the system for at least 15 minutes prior to calibration.
- If problem persist, run the latest calibration standard that passed to check for possible instrumentation problem. If it passes, this is an indication that no instrumentation problem exist, re-digest the calibration standards. If it failed, clean the lamp, prior to re-calibration.
- If problem persist, inform the supervisor for further action

12.2.2. Initial Calibration Verification (ICV) - if the ICV is non-compliant, consider the following suggestions to correct the problem:

- Run the latest ICV standard that passed to check for possible standards preparation error. If it passes, this is an indication of standards preparation error. Re-digest the ICV and re-analyze. If it fails, refer to 12.1.1 prior to re-calibration.

12.2.3. Continuing Calibration Verification (CCV) - If CCV is non-compliant, consider the following suggestions to correct the problem:

- Run the latest CCV standard that passed to check for possible standards preparation error. If it passes, this is an indication of standards preparation error. Re-digest the CCV and re-analyze. If it fails, refer to 12.1.1 prior to re-calibration.

12.3. **Sample Prep QC**

12.3.1. For insufficient amount of sample(s), inform the supervisor immediately for further action.

12.3.2. Method Blank (MB) - if MB is non-compliant, consider the following suggestions to correct the problem:

- Check the sample results. If sample results are non-detected, you may report the result upon concurring with the PM, otherwise perform the corrective action as specified in the PSR.

12.4. **Sample Analysis QC**

12.4.1. Lab Control Sample (LCS) - If LCS is non-compliant, consider the following suggestions to correct the problem:

- Check for errors in calculation and concentration of the analyte solution.
- Check instrument performance to determine if it is within acceptable guidelines.
- Re-calculate the data and/or re-analyze the extract if any of the above checks reveals a problem.
- If re-analysis results are the same as the initial result, consult the Supervisor for further action. If results indicate digestion problem, fill-up an NCR and order re-digestion to include the associated sample(s).

12.4.2. Matrix Spike (MS) - If MS is non-compliant, consider the following suggestions to correct the problem:

- If recovery failed to meet the acceptance criteria and sample result is > 5X the LOQ and the spike amount is > 4X the parent sample concentration, evaluate the post digestion spike sample result. Refer to Appendix 1 for acceptance criteria. If it fails to meet the acceptance criteria, perform MSA.
- If recovery failed to meet the acceptance criteria and sample result is ~ 5X the LOQ and the spike amount is > 4X of the parent sample concentration, evaluate the serial dilution sample result. Refer to Appendix 1 for acceptance criteria. If it fails to meet the acceptance criteria, perform MSA.

12.5. A Non-Conformance Report (NCR) is required when the following circumstances occur.

- Anomalies other than specified in Appendix 1, is observed.
- Sample is out of technical holding time.

12.5.1. Refer to EMAX-QA08 for NCR details.

13.0 POLLUTION PREVENTION

13.1. Mercury is a very volatile element, dangerous levels are readily attained in air. Mercury vapour should not exceed 0.1 mg/m^{-3} in air. Air saturated with the vapor at 20°C contains mercury in a concentration far greater than that limit. The danger increases at higher temperatures. It is therefore important that mercury

be handled with care. Containers of mercury must be securely covered and spillage must be avoided. Mercury must only be handled under in a well-ventilated area. Prepare all standards in the fume hoods.

13.2. Because of the toxic nature of mercury vapor, precaution must be taken to avoid its inhalation. A bypass must be included on the system to vent the mercury vapor into an exhaust hood.

13.3. Small amounts of mercury spillage can be cleaned up by addition of sulphur powder. The resulting mixture must be properly labeled and turned over to the waste disposal unit for proper disposal.

14.0 WASTE MANAGEMENT

14.1. No samples may be dumped on the laboratory sink.

14.2. Separate and properly identify all unused and expired analytical standards for proper disposal.

14.3. Place all wastes generated during analytical process in properly labeled satellite waste containers for proper collection.

14.4. Dispose all unused samples, expired analytical standards and other waste generated during the analytical process in accordance to EMAX-SM03.

15.0 SUPPLEMENTARY NOTES

15.1. **Definition of Terms**

15.1.1. Mercury – is also known as quicksilver, is a chemical (element) that occurs naturally in the environment in several forms. One form of mercury is used in thermometers. This form is called "metallic mercury". Mercury is also used in barometers and other common consumer products. Mercury can also be combined with other chemicals, such as chlorine, carbon or oxygen to form either "inorganic" or "organic" mercury compounds.

15.1.2. Analyte – The specific chemicals or components for which a sample is analyzed; may be a group of chemicals that belong to the same chemical family, and which are analyzed together.

15.1.3. Batch – is a group of samples that are prepared and/or analyzed at the same time using the same lot of reagents.

15.1.3.1. **Preparation Batch** – is composed of one to 20 samples of the same matrix, a method blank, a lab control sample and matrix spike/matrix spike duplicate.

15.1.3.2. **Analytical Batch** – is composed of prepared samples (extracts, digestates, or concentrates), which are analyzed together as a group using an instrument in conformance to the analytical requirement. An analytical batch can include samples originating from various matrices, preparation batches, and can exceed 20 samples.

15.1.4. Detection Limit (DL) – is defined as the smallest analyte concentration that can be demonstrated to be different from zero or a blank concentration at the 99% level of confidence. At the DL, the false positive rate (Type I error) is 1%.

15.1.5. Limit of Detection (LOD) – is defined as the smallest amount or concentration of a substance that must be present in a sample in order to be detected at a high level of confidence (99%). At the LOD, the false negative rate (Type II error) is 1%.

15.1.6. Limit of Quantitation (LOQ) – is at the lowest concentration that produces a quantitative result within specified limits of precision and bias. For DoD projects, the LOQ shall be set at or above the concentration of the lowest initial calibration standard.

15.1.7. Material Safety Data Sheet (MSDS) – is a written information concerning a chemical physical properties, toxicity, health standards, fire hazard and reactivity data including storage, spill and handling precautions.

15.1.8. Calibration – is a determinant measured from a standard to obtain the correct value of an instrument output.

15.1.9. Calibration Blank – is a target-analyte-free solvent subjected to the entire analytical process to establish zero baseline or background value.

15.1.10. Instrument Method – is a file generated to contain the instrument calibration and instrument parameter settings for a particular analysis.

15.1.11. Method Blank – is a target-analyte-free sample subjected to the entire sample preparation and/or analytical to monitor contamination.

15.1.12. Lab Control Sample (LCS) – is a target-analyte-free sample spiked with a verified known amount of target analyte(s) or a reference material with a certified known value subjected to the entire sample preparation and/or analytical process. LCS is analyze to monitor the accuracy of the analytical system.

15.1.13. Lab Control Sample Duplicate (LCSD) – is a replicate of LCS analyzed to monitor precision in the absence of MS/MSD sample.

15.1.14. Sample – is a specimen received in the laboratory bearing a sample label traceable to the accompanying COC. Samples collected in different containers having the same field sample ID are considered the same and therefore labeled with the same lab sample ID unless otherwise specified by the project.

15.1.15. Sample Duplicate – is a replicate of a sub-sample taken from one sample, prepared and analyzed within the same preparation batch.

15.1.16. Sub-sample – is an aliquot taken from a sample for analysis. Each sub-sample is uniquely identified by the sample preparation ID.

15.1.17. Matrix – is a component or form of sample.

15.1.18. Matrix Spike (MS) – is a sample spiked with a verified known amount of target analyte(s) subjected to the entire sample preparation and/or analytical process. MS is analyzed to monitor matrix effect on a method's recovery efficiency.

15.1.19. Matrix Spike Duplicate (MSD) – is a replicate of MS analyzed to monitor precision or recovery.

15.1.20. Reagent Water – Purified water free from any target analyte or any other substances that may interfere with the analytical process.

15.2. **Application of EMAX QC Procedures**

15.2.1. The procedures and QC criteria summarized in this SOP applies to all projects when performing Mercury analysis by Cold Vapor Absorption Technique. In instances where there is a project or program QAPP, the requirements given in the project takes precedence over this SOP.

15.3. **Department of Defense (DoD) Projects**

15.3.1. Samples from DoD sponsored projects follows the Quality Assurance Project Plan (QAPP), Statement of Work (SOW) and/or client's quality control directive. In the absence of QAPP, the DoD Quality Systems Manual (QSM), latest update, is applied.

15.4. **Department of Energy (DoE) Projects**

15.4.1. Samples from DoE sponsored projects follows the Quality Assurance Project Plan (QAPP), Statement of Work (SOW) and/or client's quality control directive. In the absence of QAPP, the DoE Quality Systems for Analytical Services (QSAS), latest update, is applied.

16.0 REFERENCES

16.1. Method 7470A, Test Methods for Evaluating Solid Wastes, USEPA SW-846, 1992.

16.2. EMAX Quality Systems Manual, as updated.

17.0 APPENDICES

17.1. **Figures**

17.1.1. Figure 1 Autosampler Layout

17.1.2. Figure 2 Typical Calibration Curve

17.1.3. Figure 3 Typical Sample Result Summary

17.1.4. Figure 4 Typical LCS/LCSD Summary

17.1.5. Figure 5 Typical MS/MSD Summary

17.1.6. Figure 6 Typical Analytical Spike Summary

17.1.7. Figure 7 Typical Dilution Test Summary

17.1.8. Figure 6 Typical Case Narrative

17.2. **Appendices**

17.2.1. Appendix 1 Summary of Quality Control Procedures

17.2.2. Appendix 2 Demonstration of Capability

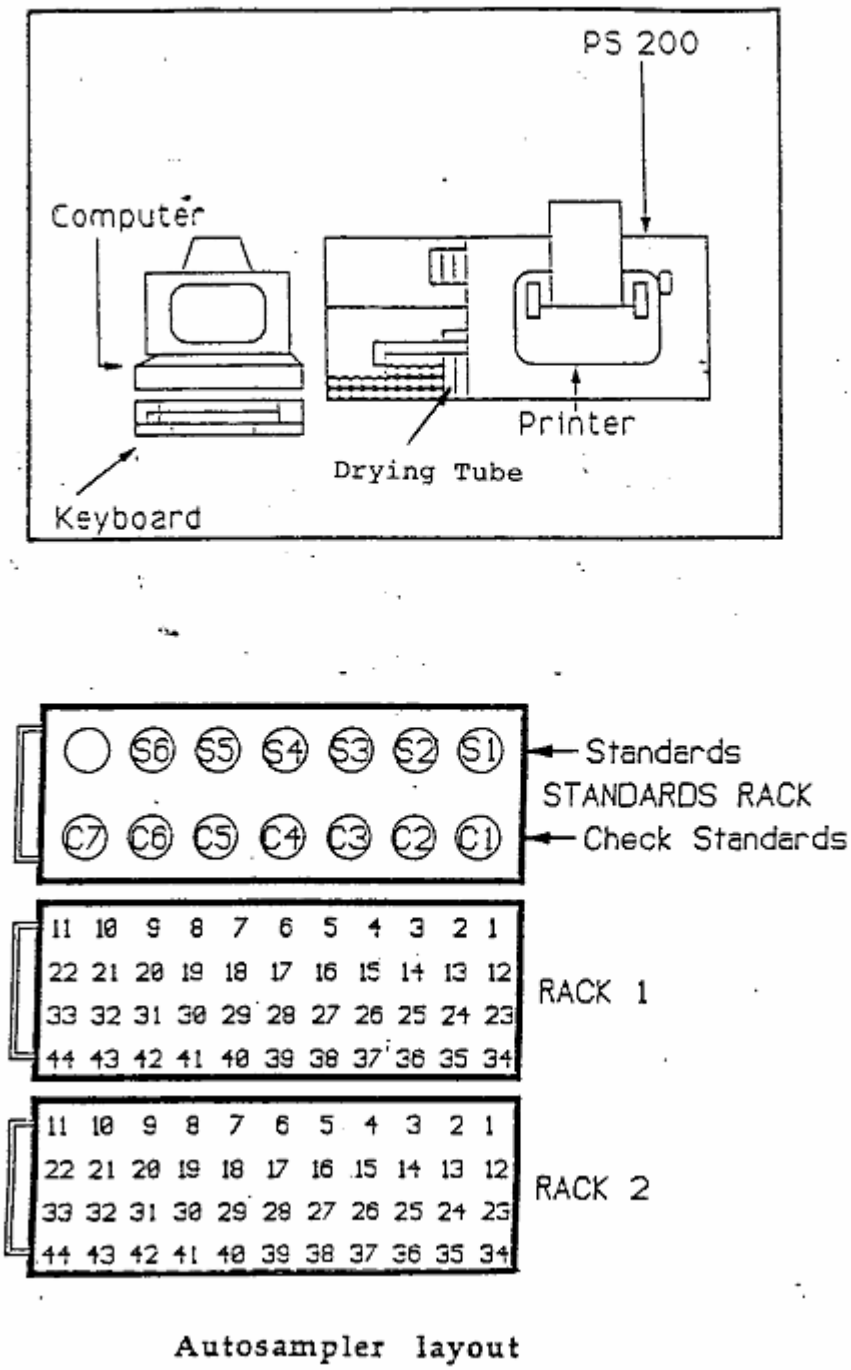
17.3. **Forms**

17.3.1. 7470FS Sample Preparation Log

17.3.2. 7470FA Analytical Run Log

17.3.3. 7470FM Instrument Maintenance Log

Figure 1: **AUTOSAMPLER LAYOUT**



Autosampler layout

Figure 2: **TYPICAL CALIBRATION CURVE**

```
RunProt: HGCOM
RunFold: M47H017  Seq: 6    Batch:
                  Prnt: R/T On                    Pump: On
                  Rev: 4.2    18:04:18 20 Aug 2012 Xmit: Off Gas:    0.35 LPM
State: Idle                                       User: MT          A/S: On
CALIBRATION:  Line   proto: HGCOM
     Hg                        Accepted
    Conc.   Calc.    Dev. ->linear
S1  .000    .034    .034    Quadratic
S2  .200    .197   -.003    Wtdlinear
S3  1.00    .998   -.002            C
S4  2.00    1.95   -.055    Accept  o
S5  5.00    5.03    .031            n
S6  10.0    10.0   -.005            c
A   .0000000      r    .999965
B   1.2551Oe-5    C   -3.7625Be-2
      Mean                                  Relative Absorbance
S1      5738        0 SD      5738
S2     18655        0 %RSD   18655
S3     82500        0 %RSD   82500
S4    157971        0 %RSD  157971
S5    403835        0 %RSD  403835
S6    799375        0 %RSD  799375

New cal coefficients stored
```

Figure 3: **TYPICAL SAMPLE RESULT SUMMARY**

METHOD 7470A
MERCURY BY COLD VAPOR

Client : XYZ, INC.
Project : CLEAN WATER PROJECT
Batch No. : 12H108

Matrix : WATER
Instrument ID : TI047

SAMPLE ID	EMAX SAMPLE ID	RESULTS (ug/L)	DLF	MOIST	RL (ug/L)	MDL (ug/L)	Analysis DATETIME	Extraction DATETIME	LFID	CAL REF	PREP BATCH	Collection DATETIME	Received DATETIME
MBLK1W	HGH024WB	ND	1	NA	0.500	0.100	08/20/1218:15	08/20/1213:15	M47H017010	M47H017008	HGH024W	NA	08/20/12
LCS1W	HGH024WL	5.14	1	NA	0.500	0.100	08/20/1218:17	08/20/1213:15	M47H017011	M47H017008	HGH024W	NA	08/20/12
LCD1W	HGH024WC	5.14	1	NA	0.500	0.100	08/20/1218:19	08/20/1213:15	M47H017012	M47H017008	HGH024W	NA	08/20/12
MW-6AS	H108-05A	5.19	1	NA	0.500	0.100	08/20/1218:21	08/20/1213:15	M47H017013	M47H017008	HGH024W	08/16/12	08/16/12
MW-6	H108-05	ND	1	NA	0.500	0.100	08/20/1218:23	08/20/1213:15	M47H017014	M47H017008	HGH024W	08/16/12	08/16/12
MW-6DL	H108-05J	ND	5	NA	2.50	0.500	08/20/1218:25	08/20/1213:15	M47H017015	M47H017008	HGH024W	08/16/12	08/16/12
MW-6MS	H108-05M	5.43	1	NA	0.500	0.100	08/20/1218:27	08/20/1213:15	M47H017016	M47H017008	HGH024W	08/16/12	08/16/12
MW-6MSD	H108-05S	5.47	1	NA	0.500	0.100	08/20/1218:29	08/20/1213:15	M47H017017	M47H017008	HGH024W	08/16/12	08/16/12
Tt-MW33	H108-02	ND	1	NA	0.500	0.100	08/20/1218:31	08/20/1213:15	M47H017018	M47H017008	HGH024W	08/16/12	08/16/12
MW-7	H108-03	ND	1	NA	0.500	0.100	08/20/1218:33	08/20/1213:15	M47H017019	M47H017008	HGH024W	08/16/12	08/16/12
MW-5	H108-04	ND	1	NA	0.500	0.100	08/20/1218:40	08/20/1213:15	M47H017022	M47H017020	HGH024W	08/16/12	08/16/12
MW-3	H108-06	ND	1	NA	0.500	0.100	08/20/1218:42	08/20/1213:15	M47H017023	M47H017020	HGH024W	08/16/12	08/16/12
MW-2	H108-07	ND	1	NA	0.500	0.100	08/20/1218:44	08/20/1213:15	M47H017024	M47H017020	HGH024W	08/16/12	08/16/12
Tt-MW32	H108-09	ND	1	NA	0.500	0.100	08/20/1218:46	08/20/1213:15	M47H017025	M47H017020	HGH024W	08/16/12	08/16/12
Tt081612EB	H108-11	ND	1	NA	0.500	0.100	08/20/1218:50	08/20/1213:15	M47H017027	M47H017020	HGH024W	08/16/12	08/16/12
MW-1	H108-08	ND	1	NA	0.500	0.100	08/20/1220:29	08/20/1213:15	M47H017072	M47H017068	HGH024W	08/16/12	08/16/12
GMT-11	H108-10	ND	1	NA	0.500	0.100	08/21/1210:51	08/20/1213:15	M47H018010	M47H018008	HGH024W	08/16/12	08/16/12

Figure 4: **TYPICAL LCS/LCSD SUMMARY**

EMAX QUALITY CONTROL DATA
LCS/LCD ANALYSIS

CLIENT: XYZ, INC.
PROJECT: CLEAN WATER PROJECT
SDG NO.: 12H108
METHOD: METHOD 7470A

MATRIX:	WATER			% MOISTURE:	NA
DILTN FACTR:	1	1	1		
SAMPLE ID:	MBLK1W				
CONTROL NO.:	HGH024WB	HGH024WL	HGH024WC		
LAB FILE ID:	M47H017010	M47H017011	M47H017012		
DATIME EXTRCTD:	08/20/1213:15	08/20/1213:15	08/20/1213:15	DATE COLLECTED:	NA
DATIME ANALYZD:	08/20/1218:15	08/20/1218:17	08/20/1218:19	DATE RECEIVED:	08/20/12
PREP. BATCH:	HGH024W	HGH024W	HGH024W		
CALIB. REF:	M47H017008	M47H017008	M47H017008		

ACCESSION:

PARAMETER	BLNK RSLT ug/L	SPIKE AMT ug/L	BS RSLT ug/L	BS % REC	SPIKE AMT ug/L	BSD RSLT ug/L	BSD % REC	RPD %	QC LIMIT %	MAX RPD %
Mercury	ND	5	5.14	103	5	5.14	103	0	80-120	20

Figure 5: **TYPICAL MS/MSD SUMMARY**

EMAX QUALITY CONTROL DATA
MS/MSD ANALYSIS

CLIENT: XYZ, INC.
PROJECT: CLEAN WATER PROJECT
SDG NO.: 12H108
METHOD: METHOD 7470A

MATRIX:	WATER			% MOISTURE:	NA
DILTN FACTR:	1	1	1		
SAMPLE ID:	MW-6				
CONTROL NO.:	H108-05	H108-05M	H108-05S		
LAB FILE ID:	M47H017029	M47H017031	M47H017034		
DATIME EXTRCTD:	08/20/1213:15	08/20/1213:15	08/20/1213:15	DATE COLLECTED:	08/16/12
DATIME ANALYZD:	08/20/1218:55	08/20/1219:00	08/20/1219:06	DATE RECEIVED:	08/16/12
PREP. BATCH:	HGH024W	HGH024W	HGH024W		
CALIB. REF:	M47H017020	M47H017020	M47H017032		

ACCESSION:

PARAMETER	SMPL RSLT ug/L	SPIKE AMT ug/L	MS RSLT ug/L	MS % REC	SPIKE AMT ug/L	MSD RSLT ug/L	MSD % REC	RPD %	QC LIMIT %	MAX RPD %
Mercury	ND	5	5.19	104	5	5.23	105	1	80-120	20

Figure 6: TYPICAL ANALYTICAL SPIKE SUMMARY

EMAX QUALITY CONTROL DATA
ANALYTICAL SPIKE ANALYSIS

CLIENT: XYZ, INC.
PROJECT: CLEAN WATER PROJECT
SDG NO.: 12H108
METHOD: METHOD 7470A

MATRIX:	WATER		% MOISTURE:	NA
DILTN FACTR:	1	1		
SAMPLE ID:	MW-6			
CONTROL NO.:	H108-05	H108-05A		
LAB FILE ID:	M47H017014	M47H017013		
DATIME EXTRCTD:	08/20/1213:15	08/20/1213:15	DATE COLLECTED:	08/16/12
DATIME ANALYZD:	08/20/1218:23	08/20/1218:21	DATE RECEIVED:	08/16/12
PREP. BATCH:	HGH024W	HGH024W		
CALIB. REF:	M47H017008	M47H017008		

ACCESSION:

PARAMETER	SMPL RSLT (ug/L)	SPIKE AMT (ug/L)	AS RSLT (ug/L)	AS % REC	QC LIMIT (%)
Mercury	ND	5	5.19	104	85-115

Figure 7: TYPICAL DILUTION TEST SUMMARY

EMAX QUALITY CONTROL DATA
SERIAL DILUTION ANALYSIS

CLIENT: XYZ, INC.
PROJECT: CLEAN WATER PROJECT
BATCH NO.: 12H108
METHOD: METHOD 7470A

MATRIX:	WATER		% MOISTURE:	NA
DILUTION FACTOR:	1	5		
SAMPLE ID:	MW-6	MW-6DL		
EMAX SAMP ID:	H108-05	H108-05J		
LAB FILE ID:	M47H017014	M47H017015		
DATE EXTRACTED:	08/20/1213:15	08/20/1213:15	DATE COLLECTED:	08/16/12
DATE ANALYZED:	08/20/1218:23	08/20/1218:25	DATE RECEIVED:	08/16/12
PREP. BATCH:	HGH024W	HGH024W		
CALIB. REF:	M47H017008	M47H017008		

ACCESSION:

PARAMETER	SMPL RSLT (ug/L)	SERIAL DIL RSLT (ug/L)	DIF RSLT %	QC LIMIT (%)
Mercury	ND	ND	0	10

Figure 8: TYPICAL CASE NARRATIVE

CASE NARRATIVE

Client : XYZ, INC.

Project : CLEAN WATER PROJECT

SDG : 12H108

METHOD 7470A
MERCURY BY COLD VAPOR

A total of ten (10) water samples were received on 08/16/12 for Mercury analysis, Method 7470A in accordance with USEPA SW-846, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods.

Holding Time
Samples were analyzed within the prescribed holding time.

Calibration
Multi-calibration points were generated to establish initial calibration (ICAL). ICAL was verified using a secondary source. Continuing calibration verifications were carried out at the frequency specified by the project. All calibration requirements were within acceptance criteria.

Method Blank
Method blank was analyzed at the frequency required by the project. For this SDG, one method blank was analyzed with the samples. Result was compliant to project requirement.

Lab Control Sample
A set of LCS/LCD was analyzed with the samples in this SDG.
Percent recoveries for HGH024WL/C were all within QC limits.

Matrix QC Sample
Matrix QC sample was analyzed at the frequency prescribed by the project.
Percent recoveries for H108-05M/S were within project QC limits.
In addition Analytical spike and serial dilution were analyzed for matrix interference evaluation. Results were within method acceptance criteria.

Sample Analysis
Samples were analyzed according to prescribed analytical procedures. All project requirements were met otherwise anomalies were discussed within the associated QC parameter.

Appendix 1: SUMMARY OF QUALITY CONTROL PROCEDURES

PARAMETER	FREQUENCY	ACCEPTANCE CRITERIA	CORRECTIVE ACTION	1st Rvw	2nd Rvw
Initial multipoint calibration	Daily initial calibration prior to sample analysis	Correlation coefficient r≥ 0.995 for linear regression	Correct the problem then repeat initial calibration		
Initial calibration verification (second source)	Daily after initial calibration	Analyte within ± 10% of expected value	Correct the problem then repeat initial calibration		
Calibration verification (CCV)	Daily, before sample analysis, every 10 samples and at the end of analysis sequence	Analyte within ± 20% of expected value	Repeat calibration and re-analyze all samples since last successful calibration		
Calibration blank (CCB)	After every calibration verification	No analyte detected > LOD	Correct the problem then re-analyze calibration blank and previous samples		
Method blank (MB)	One per preparation batch	No analyte detected > ½ LOQ	Re-prep and re-analyze method blank and all samples processed with the contaminated blank		
Lab Control Sample (LCS)	One LCS per preparation batch	%Rec.: 80-120%	Re-prep and re-analyze the LCS and all associated samples		
MS/MSD or MS/Dup	One set MS/MSD or MS/Dup in every preparatory batch	%Rec. 80-120%, RPD≤ 20%	Perform Post-Digestion Spike.		
Post-Digestion Spike	When MS/MSD or MS/Dup fails	%Rec. 85-115%	Perform dilution test if analyte concentration is sufficiently high (~5x the LOQ after dilution), otherwise perform MSA.		
Dilution Test	When Post-Digestion Spike fails and analyte concentration is sufficiently high (~5x the LOQ after dilution)	Within ± 10% of the parent sample result	Perform MSA.		
Comments: Refer to PSR for flagging criteria LOQ = lowest calibration point			Reviewed By:		
			Date:		

Appendix 2: DEMONSTRATION OF CAPABILITY

DEMONSTRATION OF CAPABILITY
MERCURY
METHOD SW 7470

SOP: EMAX-7470
Conc Unit: mg/L
Sample Amount(mL): 50

Extraction dates: 12/21/2011
Analysis dates: 12/21/2011
Extracted and Analyzed by: N. Tan

PARAMETER	HGL013WL	HGL013WC	HGL014WL	HGL014WC	TV	Ave. Conc.	Ave. %Rec	SD	RSD (%)	QC Criteria	COMMENTS
	M47L014-11	M47L014-12	M47L014-61	M47L014-62							
Mercury	5.18	5.11	5.13	5.17	5	5.15	103	0.033	1	80 - 120	PASSED

7470FS: **SAMPLE PREPARATION LOG**

EMAX LABORATORIES, INC.

DIGESTION LOG *for* MERCURY

Page 1

Note: For samples, relevant QCs/Standards digested, refer to attached digestion sequence.

Comments:

Book #: E47-089

Batch No.:

Matrix:

SOP #	Rev. #
☐ EMAX-7470	
☐ EMAX-7471	
☐ EMAX-245.1	
☐ EMAX-	

Standards	ID	Conc. (µg/L)	Amount Added (ml)
ICAL			
CCV			
ICV			
LCS/MS			

Reagent	ID / Lot #
HNO_3	
HCl	
H_2SO_4	
$KMnO_4$	
$K_2S_2O_8$	
$NH_2OH{\bullet}HCl$	
$SnCl_2$	
Silica Sand	
pH strip 0-14	

Digestor ID/ Temp (°C)

Thermometer ID:

Pipette ID:

☐ H_2SO_4 dispenser checked @ 2.5 ml with Class A graduated cylinder

☐ HCl dispenser checked @ ___ ml with Class A graduated cylinder

☐ HNO_3 dispenser checked @ ___ ml with Class A graduated cylinder

Prepared By:

Standard Added By: Witnessed By:

7470FA: **ANALYTICAL RUN LOG**

EMAX LABORATORIES, INC.

ANALYSIS RUN LOG
for
MERCURY

Page 1

Note: For samples and relevant QCs/Standards analyzed, refer to attached analytical sequence.

Start Date: **Start Time:**

End Date: **End Time:**

Comments:

Book #: A47-085

Instrument No.: 47

Analytical Sequence/Batch:

Method File:

Micropipette ID: ☐ ICP DOE-1

Micropipette ID: ☐ HG-03

Micropipette ID: ☐ HG-04

Micropipette ID: ☐

SOP #	Rev. #
☐ EMAX-7470	
☐ EMAX-7471	
☐ EMAX-245.1	
☐ EMAX-	

STANDARDS ID
S1
S2
S3
S4
S5
S6
CCV
ICV
LCS
Analytical Spike

Analyzed By:

Date:

7470FM: INSTRUMENT MAINTENANCE LOG

EMAX LABORATORIES, INC.

Page 1

INSTRUMENT MAINTENANCE LOG

Instrument No: 47 Month: Year: 201_ Book #: M47-010

DAQ TEST							
Sample: 700,000 - 1,720,000							
Hg Lamp Volt: 8.0-9.5							
GAS CONTROL TEST							
Argon Input Pressure: 75-90 psi							
Power Supply Voltage: 5V+/-0.25, +12V+/-0.5, -12V+/-0.5							
Gas: 0-1.0 LPM							
Pump Rate: 2-15 ml/min							
Instrument Warm-up: Minimum 5 mins							
Peristaltic Pump							
Tubings Pump/Capillary							
Fume Hood							
Reductant Bottle							
Rinse Solution							
Computer Date/Time							
Printer Paper							
Analyst Initial							
Trouble Shooting							
Problem(s) Encountered							
Return to Specs (Analyst Initial)							

Code	Problems Encountered	Code	Corrective Action

STANDARD OPERATING PROCEDURES

VOLATILE ORGANICS BY GC/MS

SOP No.:	EMAX-8260	Revision No.	8	Effective Date:	29-Jun-11
Prepared By:	Souzan Greas			Date:	06-29-11
Approved By:	Kenette Pimentel QA Manager			Date:	06.29.11
Approved By:	Caspar Pang Laboratory Director			Date:	06-29-11

Control Number: 8260-08-

1.0 SCOPE AND APPLICATION

1.1. This analytical method is used to determine the concentration of volatile organic compounds whose boiling points are below 200°C and are water insoluble or slightly water-soluble found in solid or liquid samples. The list of compounds is summarized in Tables 7 and 8. Additional analytes may be added after verification. This SOP is an adaptation of Method 8260B.

2.0 SUMMARY OF METHOD

2.1. A measured sample is extracted using a purge and trap concentrator system. The extract is introduced to a temperature-programmed GC. The analytes are eluted through the GC column separating each analyte relative to its volatility. These analytes are captured and ionized by the mass spectrometer. The ionized fragments are measured by mass to charge ratio. Analyte qualitative identification is based on the characteristic electron impact mass spectra. Analyte quantitative identification is based on the response of the major ion relative to an internal standard using a multi-point calibration curve.

2.2. **Interferences**

2.2.1. Contamination may occur by diffusion of volatile organics (particularly chlorofluorocarbons and methylene chloride) through sample container septum during shipment and storage. Trip blanks and storage blanks can serve as means of monitoring.

2.2.2. Glassware and other sample processing materials in which the samples come into contact with are possible sources of contamination. All glassware and other materials used must be purchased pre-cleaned or decontaminated prior to use.

2.2.3. Solvents and reagents are possible sources of contamination. All solvents and reagents must be GC grade and must pass the QC checks prior to use.

2.2.4. Contamination by carry-over can occur whenever high concentration samples are analyzed in sequence with a low concentration sample. To reduce potential carry-over, the concentrator must be thoroughly baked-out between samples and the sample syringe and purging device must be thoroughly rinsed with an appropriate solvent between samples.

2.2.5. Another possible source of contamination is the analytical instrument itself. This can be monitored by analyzing an instrument blank prior to any analysis.

3.0 DETECTION LIMITS

3.1. **Detection Limit (DL), Limit of Detection (LOD) & Limit of Quantitation (LOQ)**

3.1.1. Refer to EMAX-QA04 for generation, validation and verification for DL, LOD and LOQ.

3.1.2. Refer to Table 7 for established DL, LOD and LOQ levels.

4.0 DYNAMIC RANGE

4.1. The highest quantifiable concentration requiring no dilution is equal to the highest calibration point (see Sec. 9.4). All samples analyzed above this concentration are considered "over-range" and shall require dilution to properly quantitate.

4.2. The concentration in the diluted sample should be at or above the project reporting limit. All diluted samples analyzed below this concentration are considered "under-range". A lower dilution factor is required to properly quantitate.

4.3. **Typical Dynamic Range**

4.3.1. Water: 5 µg/L to 200 µg/L (5 ml purge)

1 µg/L to 40 µg/L (25 ml purge)

4.3.2. Soil: 5 µg/kg to 200 µg/kg

5.0 SAMPLE HOLDING TIME AND PRESERVATION

5.1. **Aqueous Samples**

5.1.1. Samples received in the laboratory should be contained in 40 ml vials with teflon lined septa with zero headspace.

Note: The size of any bubble caused by degassing upon cooling the sample should not exceed 6 mm.[1]

5.1.2. All samples must be stored at ≤ 6°C without freezing.

ADD

5.1.3. Samples preserved in HCL shall be analyzed within 14 days from the date of sampling. Samples with no chemical preservative must be analyzed within 7 days from the date of sampling.

5.2. **Soil Samples**

5.2.1. Samples receive in a glass jars or brass tubes shall be stored at ≤ 6°C without freezing. Samples must be analyzed within 14 days from sampling date.

5.2.2. Samples received in encore tubes are frozen, preserved with sodium bisulfate or extracted with methanol prior to analysis.

- Frozen encore tubes must be analyzed within 14 days from sampling date.
- Samples preserved with sodium bisulfate within 48 hours from sampling date must be analyzed within 14 days from sampling date.
- Methanol extracts shall be analyzed within 14 days from sampling date.
- Preserved samples and extracts shall be stored at ≤ 6°C without freezing.

[1] Referenced from SW846 Method 5030B, Section 6.1.

6.0 ASSOCIATED SOPs

6.1. EMAX-5030 - Purge and Trap For Aqueous Samples

6.2. EMAX-5035 - Closed-System Purge and Trap For Solid Samples

6.3. EMAX-DM01- Data Flow and Review

6.4. EMAX-QA04 - Method Detection Limit

6.5. EMAX-QA05 - Training

6.6. EMAX-QA08 - Corrective Action

6.7. EMAX-QC01 - Quality Control for Chemicals

6.8. EMAX-QC02 - Analytical Standard Preparation

6.9. EMAX-QC07 - Glassware Cleaning

6.10. EMAX-SM01 - Sample Management

6.11. EMAX-SM03 - Waste Disposal

6.12. EMAX-SM04 - Analytical and QC Sample Labeling

7.0 SAFETY

7.1. Read all MSDS of chemicals listed in this SOP.

7.2. All reagents, standards, and samples shall be treated as potential hazards. Observe standard laboratory safety procedures. Protective gear, i.e., lab coat, safety glasses, and gloves, shall be worn at all times when performing this procedure. All sample and standard handling shall be performed in the fume hood.

7.3. All waste generated during analytical process shall be placed in the waste containers. Waste shall be endorsed to the waste disposal section for proper disposal.

7.4. If for any reason, solvent and/or other reagents get in contact with the skin or any other part of the body, rinse the affected body part thoroughly with tap water. If irritations persist, inform your supervisor immediately so that proper action can be taken.

8.0 INSTRUMENTS, CHEMICALS AND REAGENTS

8.1. **Instruments and Supplies**

Gas Chromatography	HP 5890 Series II or equivalent
Detector	HP 5971 MSD or equivalent
Column	RTX 502.2 (0.32 mm x 60 m), 1.8um thickness or equivalent after verification that the four gases (chloromethane, bromomethene, chloroethane, and vinyl chloride) can be resolved > 90% from each other in the total ion chromatogram
Data Acquisition Software	ChemStation or equivalent
Purge & Trap Device	OI 4560/Encon Evolution/EST or equivalent

Multiple purging module	Archon/Centurion or equivalent
Gases	Ultra-high purity helium/Air
Syringes	5 ml, 25 ml Luerlok gas-tight
Microsyringes	1, 10, 20, 25, 50, 100, and 1000 µL (Hamilton 702N or equivalent) for dilution purposes
Volumetric Flasks	2,5,10, 50, and 100 ml with ground glass stopper
Heated Sparge	Archon or Automatic sample heating jacket or equivalent

8.2. **Chemicals and Reagents**

Extraction Solvent	Purge & Trap Grade Methanol or equivalent
Reagent Water	Organic-free water
Reagent Soil	Organic-free Ottawa Sand or equivalent
Preservative	Sodium Bisulfate

9.0 STANDARDS

9.1. Standard preparation for VOA is summarized in Tables 1 to 4. Refer to EMAX-QC02 for proper analytical standard preparation. Other concentration levels may be prepared provided it complies with the method and project requirements.

9.2. **Stock Standard**

9.2.1. Purchase Stock Standards as certified solutions.

9.2.2. Purchase one set of calibration standard (refer to Table 1) for calibration and a secondary source Stock Standard for calibration verification (refer to Table 2).

9.2.3. Purchase Surrogate Mix at 2500 mg/L and Internal Standard at 2500 mg/L (refer to Table 3).

9.2.4. Purchase BFB as Tuning Standard at 5000 mg/L (refer to Table 4).

9.2.5. After opening, transfer in inert vials with minimal headspace and store at -10°C to -20°C.

9.3. **Intermediate Standards**

9.3.1. Using the stock standard solutions, prepare intermediate standards in methanol according to Tables 1 to 4 and store with minimal headspace in an inert vial.

9.4. **Initial Calibration Standards (ICAL)**

9.4.1. ICAL for 5 ml Purge.

9.4.1.1. Using intermediate standards (refer to Tables 1 and 3), prepare multi calibration standards as suggested below.

Calibration Pt.	VOA (µg/L)*	Surrogate (µg/L)	Internal Std (µg/L)
1	5	5	50

2	10	10	50
3	20	20	50
4	50	50	50
5	100	100	50
6	200	200	50

** Ketones, Acrolein, Acrylonitrile and tert-Butanol are 5X the indicated concentration and m/p-Xylene is 2x the indicated concentration.*

9.4.2. ICAL for 25 ml Purge

9.4.2.1. Using intermediate standards (refer to Tables 1 and 3), prepare multi calibration standards as suggested below:

Calibration Pt.	VOA (µg/L)*	Surrogate (µg/L)	Internal Std (µg/L)
1	0.5	0.5	10
2	1	1	10
3	2	2	10
4	10	10	10
5	20	20	10
6	40	40	10

** Ketones, Acrolein, Acrylonitrile and tert-Butanol are 5X the indicated concentration and m/p-Xylene is 2x the indicated concentration.*

9.5. **Initial Calibration Verification Standard (ICV)**

9.5.1. Using the Intermediate Standard prepared from the secondary source (refer to Tables 2 and 3), spike into 5 ml or 25 ml purge as suggested below.

9.5.1.1. ICV for 5 ml purge

ICV	VOA* (µg/L)	Surrogate (µg/L)	Internal Standard (µg/L)
5 ml	50	50	50

** Ketones, Acrolein, Acrylonitrile and Tert-Butanol are 5x the indicated concentration and M/P-xylene is 2X the indicated concentration.*

9.5.1.2. ICV for 25 ml purge

ICV	VOA* (µg/L)	Surrogate (µg/L)	Internal Standard (µg/L)
25 ml	10	10	10

** Ketones, Acrolein, Acrylonitrile and Tert-Butanol are 5x the indicated concentration and M/P-xylene is 2X the indicated concentration.*

9.6. **Daily Calibration Check Standard (DCC)**

9.6.1. Using the Intermediate Standard prepared from the same source as the ICAL Standard (refer to Tables 1 and 3), spike into 5 ml or 25 ml purge as suggested below.

9.6.1.1. DCC for 5 ml purge

DCC	VOA* (µg/L)	Surrogate (µg/L)	Internal Standard (µg/L)
5 ml	50	50	50

** Ketones, Acrolein, Acrylonitrile and Tert-Butanol are 5x the indicated concentration and M/P-xylene is 2X the indicated concentration.*

9.6.1.2. DCC for 25 ml purge

DCC	VOA* (µg/L)	Surrogate (µg/L)	Internal Standard (µg/L)
10	10	10	10

** Ketones, Acrolein, Acrylonitrile and Tert-Butanol are 5x the indicated concentration and M/P-xylene is 2X the indicated concentration.*

9.7. **LCS and Matrix Spike Standard**

9.7.1. For spike standards, use the Intermediate Standard prepared from the secondary source (refer to Tables 2 and 3), spike into the 5 ml or 25 ml purge as suggested below (unless otherwise specified by the project).

9.7.1.1. LCS and Matrix Spike for 5 ml purge

LCS or MS/MSD	VOA* (µg/L)	Surrogate (µg/L)	Internal Standard (µg/L)
5 ml	50	50	50

** Ketones, Acrolein, Acrylonitrile and Tert-Butanol are 5x the indicated concentration and M/P-xylene is 2X the indicated concentration.*

9.7.1.2. LCS and Matrix Spike for 25 ml purge

LCS or MS/MSD	VOA* (µg/L)	Surrogate (µg/L)	Internal Standard (µg/L)
25 ml	10	10	10

** Ketones, Acrolein, Acrylonitrile and Tert-Butanol are 5x the indicated concentration and M/P-xylene is 2X the indicated concentration.*

10.0 PROCEDURES

ADD

10.1. **Sample Preparation**

10.1.1. Refer to EMAX-5030 and EMAX-5035.

10.2. **Instrument Parameters**

10.2.1. From the main gas supply (gas Tanks) regulate gas pressure at 80 psi.

10.1.1. Fine-tune the instrument guided by the parameter conditions suggested below. Adjust the parameter conditions accordingly to obtain optimum condition. Print the instrument parameter and post it on the instrument for daily routine maintenance check.

10.2.2. Typical GC Parameters

Carrier gas flow (column) helium	1 – 5 ml/min
Initial Temp	35°C; hold for 1 min.
Rate 1	8°C/min. to 160°C/min
Rate 2	30°C/min to 230°C/min; hold for 3 min.
Inject Port	200°C
Interface	250°C

10.2.3. Mass Spectrometer Parameter

Scan Start	0.5 min.
Mass Range	35 to 300
Multiplier	1200 to 2700

10.2.4. Typical Purge and Trap Condition

10.2.4.1. Purge samples at 40°C for 11 minutes, desorbed at 250°C for 2 minutes and then bake the trap at 260°C for 11 minutes.

10.3. **Calibration**

10.3.1. Set GC/MS operating condition as described in Section 10.2.

10.3.2. Perform Tune Check

10.3.2.1. Introduce a BFB to yield 5 – 50 ng by either direct injection or purge and trap in 5 ml or 25 ml organic-free water.

10.3.2.2. Evaluate the tune check by the highest scan on the peak or the average of at least 3 scans (before, at and after the apex) with a background subtraction using a single scan no more than 20 scans prior to the elution of BFB.

10.3.2.3. Check Table 6 for acceptance criteria or follow the manufacturer's recommendation for tuning. A valid tune check expires after 12 hours.

10.3.2.4. If non-compliant refer to Section 12 for corrective action.

10.3.3. Initial Calibration (ICAL)

10.3.3.1. Perform ICAL when one of the conditions occurs.

- Instrument is new
- Instrument undergoes a major repair
- DCC failed to meet the acceptance criteria

10.3.3.2. Analyze multi-point initial calibration curve (Refer to Section 9.4) after a valid tune

check.

10.3.3.3. Check for completeness of target compound list. If there is/are missing compound(s), perform the following:

- Check the established retention time window.
- Check the relative intensity of major ions.
- Adjust accordingly if necessary.

10.3.3.4. Evaluate retention time of each analyte with respect to the nearest internal standard. The relative retention time (RRT) of each analyte should agree within ± 0.06 RRT units.

10.3.3.5. Establish a summary of Relative Response Factors for each analyte at each concentration. Calculate the Relative Response Factor (RRF), the Average Relative Response Factor (RRF_m), the Standard Deviation (SD), and the Relative Standard Deviation (RSD) according to Eq-10.5.1.1, Eq.-10.5.1.2, Eq.-10.5.1.5 and Eq.-10.5.1.6, respectively.

10.3.3.6. Evaluate System Performance Check Compounds (SPCC) and Calibration Check Compounds (CCC) as specified in Appendix 1.

10.3.3.7. Evaluate the ICAL for appropriate quantitation method.

- Use RRF_m if the RSD of individual analyte ≤ 15%.
- Apply Inverse Weighting Factor (1/y or $1/y^2$; where y is the instrument response) if it is determined to be the best fit for the specific analytes. This approach may be applied to any analyte including analyte that has RSD of ≤ 15% and correlation coefficient of ≥ 0.99.
- Apply linear least squares regression if past experience or prior knowledge of instrument response is known to be the best fit for specific analytes. This approach may be applied to any analyte including analyte that has RSD of ≤ 15% and correlation coefficient of ≥ 0.99.
- It may be appropriate to force the regression through zero for specific analytes.[2] When exercising this option (as included in the data acquisition software) make sure that the origin (0,0) is not included as a calibration point but rather the intercept is set to zero. This option shall only be applied if the curve favors better accuracy of quantitation.

10.3.3.8. Submit summary of ICAL, raw data and manual integration (if any) for secondary review.

10.3.4. Initial Calibration Verification (ICV)

10.3.4.1. Analyze ICV to verify the concentration of the ICAL standards (refer to Section 9.5).

10.3.4.2. Check for completeness of analytes as described in Section 10.4.3.

10.3.4.3. Compare the retention times of the internal standards to the ICAL mid-point. Excursion of ± 30 seconds indicates instrument malfunction. When non-compliant

[2] SW846 Method 8000B, Section 7.5.3

check the column head pressure, gas supply or leaks. Corrective action is required prior to further analysis.

10.3.4.4. Compare the area of the Internal Standards (IS) acquired against the midpoint of the initial calibration point. The extracted ion current profile (EICP) must be within a factor of two (-50% to +100%).

10.3.4.5. Refer to Appendix 1 for ICV acceptance criteria and/or corrective action.

10.3.4.6. When non-compliant refer to Section 12 for corrective action.

10.3.5. Daily Continuing Calibration (DCC)

10.3.5.1. Analyze DCC to check the validity of the ICAL (refer to 9.6).

10.3.5.2. Check for completeness of analytes as described in Section 10.4.3.

10.3.5.3. Evaluate System Performance Check Compounds (SPCC) and Calibration Check Compounds (CCC) as specified in Appendix 1.

10.3.5.4. Compare the retention times of the internal standards to the ICAL mid-point. Excursion of ± 30 seconds indicates instrument malfunction. When non-compliant check the column head pressure, gas supply or leaks. Corrective action is required prior to further analysis.

10.3.5.5. Compare the area of the Internal Standards (IS) acquired against the midpoint of the initial calibration point. The extracted ion current profile (EICP) must be within a factor of two (-50% to +100%).

10.3.5.6. Establish RRF of each analyte, calculate %D (Eq. 10.5.2.1) against the ICAL.

10.3.5.7. Refer to Appendix 1 for DCC acceptance criteria and/or corrective action.

10.3.5.8. When non-compliant refer to Section 12 for corrective action.

10.4. **Analysis**

10.4.1. Analytical Sequence

10.4.1.1. Analyze BFB and evaluate tuning

10.4.1.2. Analyze DCC and check ICAL validity

10.4.1.3. Analyze Lab Control Sample

10.4.1.4. Analyze Lab Control Sample Duplicate (if required)

10.4.1.5. Analyze Method Blank

10.4.1.6. Analyze samples to a maximum number of 12-hours from the time of BFB injection.

10.4.1.7. Analyze a pair of matrix spikes (MS/MSD) for every 20 samples of the same matrix.

10.4.1.8. Record analytical sequence in the analytical run log.

10.4.2. Sample Result Evaluation

10.4.2.1. Check the QC criteria as soon as the data is available.

- Check method blank. If result is non-compliant and analyte in question is not detected in any sample or contamination is < 10X of the sample concentration, results maybe reportable. Verify with the PM if results can be reported.
- Check surrogate recoveries against project specific requirement (PSR). In the absence of PSR, default to Appendix 1 QC limits.
- Check concentration of target analytes if calibration range is exceeded.
- If any of the above checkpoints indicate a problem, re-analysis is required. Note observations on the analytical run log. When results arise to questionable result, e.g. inconsistency from the first analysis, consult the Supervisor for further action.
- Compare the retention times of each Internal Standards (IS) to the ICAL mid point (must be ± 30 seconds).
- Compare the area of each IS acquired against the mid point of the ICAL. The Extracted Ion Current Profile (EICP) must be within a factor of two (-50 to +100%).

10.4.3. Qualitative Identification

- The intensities of the characteristic ions maximize in the same scan or within one scan of each other.
- The relative retention time (RRT) of the sample component is within 0.06 RRT units of the RRT of the standard component.
- The relative intensity of the characteristic ions agrees within 30% of the relative intensity of these ions in the reference spectrum.
- Check the chromatogram for possible misidentified analytes. Investigate visible peaks in the chromatogram that were not identified in the data output. Manually integrate the peak if necessary. For manual integration refer to EMAX-DM01.

10.4.3.1. For samples containing components not associated with the calibration standards, perform a library search for purposes of tentative identification[3] (TIC). Execute LSC (Chem Station program) to initiate the library search using NIST/EPA/MSDC mass spectral library. Visually inspect each extracted mass ion chromatograph to determine the identification of the unknown before final reporting following the guidelines below.

- Relative intensities of major ions in the reference spectrum (ions greater than 10% of the most abundant ion) should be present in the sample spectrum.
- The relative intensities of the major ions should agree within + 20%. Example: for an ion with an abundance of 50% of the standard spectra, the corresponding sample ion abundance must be between 30 and 70%.
- Molecular ions present in reference spectrum should be present in sample spectrum.

[3] Library search is performed only when indicated in the PSR.

- Ions present in the sample spectrum but not in the reference spectrum should be reviewed for possible background contamination or presence of co-eluting analytes.
- Ions present in the reference spectrum but not present in the sample spectrum should be reviewed for possible subtraction from the sample spectrum because of background contamination or co-eluting analytes. Data system library reduction programs can sometimes create these discrepancies.

10.4.3.2. **Reporting TICs**

- If the library search produces a match at or above 85%, report the analyte.
- If the library search produces more than one analyte at or above 85%, report the first analyte (highest).
- If the library search produces no matches at or above 85%, the compound should be reported as unknown.

10.4.4. Quantitation

- Apply the appropriate quantitation method (Section 10.3.3.7). Calculate the concentration of any positively identified target analyte using the appropriate equation in Section 10.5.3. Apply the dilution factor for diluted samples to calculate for the final concentration of the sample.

10.4.5. Manual Integration

10.4.5.1. Refer to EMAX-DM01 Manual Integration Section.

10.4.6. Dealing with Carryover

10.4.6.1. Check the sample analyzed after a sample having target analyte concentrations exceeding the calibration range.

10.4.6.2. If there is no target analyte detected as found in the sample that exceeded the calibration range, proceed with data reduction.

10.4.6.3. If there is any target analyte detected as found in the sample that exceeded the calibration range, re-analyze the sample to rule out carry over. If carry over is confirmed, proceed with data reduction and report the data from re-analysis.

10.4.6.4. To clean-up the autosampler purge line consider purging a 25 ml or 5 ml sample spiked with 100 µl of methanol and let it run like a blank sample. If improved result is noted repeat this process until no evidence of contamination is observed. Otherwise inform the Supervisor for further instruction.

10.5. **Calculations**

10.5.1. Initial Calibration

10.5.1.1. **Calculate for the Relative Response Factor (RRF)**

$$RRF = \frac{A_X C_{IS}}{A_{IS} C_X} \qquad \text{Eq.-10.5.1.1}$$

where:

RRF – Relative Response Factor

A_X – Area of characteristic ion for the compound being measured

A_{IS} – Area of characteristic ion for the specific internal standard

C_X – Concentration of the compound being measured

C_{IS} – Concentration of the specific internal standard

10.5.1.2. **Calculate for the Average Relative Response Factor (RRF_m)**

$$RRF_m = \frac{\sum RRF}{n}$$ Eq.-10.5.1.2

where:

RRF_m – Average response factor

$\sum RRF$ – Summation of response factors

n – Number of measurements

10.5.1.3. **Calculate for Least Square Linear Regression**

$$y = ax + b$$ Eq.-10.5.1.3

where:

y – Response ratio (A_X/A_{IS})

x – Amount ratio (C_X/C_{IS})

a – x1 = slope of the line

$$a = \frac{\sum (x-\bar{x})(y-\bar{y})}{\sum (x-\bar{x})^2}$$

where: $\bar{x}$ = average of amount ratios

$\bar{y}$ = average of response ratios

b – x0 = intercept of the line

$$b = \bar{y} - a * \bar{x}$$

10.5.1.4. **Calculate for Inverse Weighting Factor**

$$y = ax + b$$ Eq.-10.5.1.4

where:

y – Response ratio (A_X/A_{IS})

x – Amount ratio (C_X/C_{IS})

a – x1 = slope of the line

$$a = \frac{\sum (x - x_a)(y - y_a)}{\sum (x - x_a)^2}$$

where: $x_a = \sum \left[x(1/x) / \sum (1/x) \right]$

$y_a = \sum \left[y(1/x) / \sum (1/x) \right]$

or $x_a = \sum \left[x(1/x^2) / \sum (1/x^2) \right]$

$y_a = \sum \left[y(1/x^2) / \sum (1/x^2) \right]$

b – x0 = intercept of the line

$$b = y_a - a * x_a$$

10.5.1.5. **Calculate the Standard Deviation**

$$SD = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}}$$ Eq.-10.5.1.5

where:

SD – Standard deviation

x_i – Result at i^{th} measurement

$\bar{x}$ – Mean of the n measurements

n – Number of measurements

10.5.1.6. **Calculate the % relative standard deviation (%RSD)**

$$\%RSD = \frac{SD}{RRF_m} * 100\%$$ Eq.-10.5.1.6

where:

SD – Standard deviation

RRF_m – Average response factor

10.5.2. Calibration Check/Continuing Calibration

10.5.2.1. **Calculate Percent Difference (%D)**

$$\%D = \frac{[RRF_c - RRF_m]}{RRF_m} * 100\%$$ Eq.-10.5.2.1

where:

RRF_c – Response factor from continuing calibration standard

RRF_m – Average response factor

10.5.2.2. **% Drift**

$$\%Drift = \frac{[found\ Conc. - true\ Conc]}{true\ Conc.} * 100\% \qquad \text{Eq.-10.5.2.2}$$

10.5.3. Calculation of Sample Concentration (Water and Soil/Sediment Samples). When a compound is identified, the quantitation of that compound shall be based on the integrated abundance from the EICP of the primary characteristic ion.

10.5.3.1. **Water Samples**

$$Concentration\ (ug/L) = \frac{(Ax)(Is)}{(Ais)(RRF_m)}\ x\ DF \qquad \text{Eq.-10.5.3.1}$$

where:

A_x – Area of characteristic ion for the compound to be measured

I_s – Concentration of internal standard added in µg/L

A_{is} – Area of characteristic ion for the internal standard

RRF_m – Average response factor

DF – Dilution factor = $\frac{purge\ volume\ in\ ml\ \ (5\ ml\ or\ 25\ ml)}{sample\ \ amount\ \ in\ ml}$

10.5.3.2. **Soil/Sediment Samples (Dry weight basis)**

$$Concentration\ (ug/kg) = \frac{(Ax)(Is)}{(Ais)(RRF_m)(DW)}\ x\ DF \qquad \text{Eq.-10.5.3.2}$$

where:

A_x – Area of characteristic ion for the compound to be measured

I_s – Concentration of internal standard added in µg/L

A_{is} – Area of characteristic ion for the internal standard

RRF_m – Average response factor

DF – Dilution factor = $\frac{5\ g}{(sample\ \ amount\ \ in\ g)}$

DW – % solid = $\frac{100 - \%moisture}{100}$

10.5.3.3. **Extracted Soil/Sediment Samples (Dry weight basis)**

$$Concentration\ (ug/kg) = \frac{(Ax)(Is)}{(Ais)(RRF_m)(DW)}\ x\ DF \qquad \text{Eq.-10.5.3.3}$$

where:

A_x – Area of characteristic ion for the compound to be measured

I_s – Concentration of internal standard added in µg/L

A_{is} – Area of characteristic ion for the internal standard

RRF_m – Average response factor

DF – Dilution factor = $\frac{(purged\ \ volume\ \ in\ \mu L)(5\,g)}{(extract\ \ aliquot\ \ in\ \mu L)(sample\ \ amount\ \ in\ g)}$

DW – % solid = $\frac{100 - \%moisture}{100}$

10.5.4. Alternatively, the regression line (area ratio of Ax/Ais versus concentration using first degree) fitted to the initial calibration may be used for determination of the sample concentration when RSD of the analyte is greater than 15% (Section 10.3.3.7).

10.5.5. Concentration of TIC is estimated by the same method as target compounds with the following assumptions:

10.5.5.1. The area Ax and Ais are derived from total ion chromatogram. Ais refers to the closest internal standard (IS) free of interference.

10.5.5.2. RRF of the TIC is 1.

10.5.6. Method Proficiency

10.5.6.1. **Percent Recovery**

$$\%\ Recovery = \frac{C_f - C}{C_s} * 100\% \qquad \text{Eq.-10.5.6.1}$$

where:

C_f – Concentration found

C – Concentration of sample (use 0 for LCS)

C_s – Concentration of spike

10.5.6.2. **Relative Percent Difference (%RPD)**

$$\%\ RPD = \frac{|C_1 - C_2|}{\left(\frac{C_1 + C_2}{2}\right)} \times 100 \qquad \text{Eq.-10.5.6.2}$$

where:

RPD – Relative Percent Difference

$C1$ – Measured concentration of the first sample aliquot

$C2$ – Measured concentration of the second sample aliquot

10.6. **Data Reduction**

10.6.1. Make a copy of the analytical run log and highlight the data to be reported.

10.6.2. Print a copy of the raw data and the QC report.

10.6.3. Check that all positively identified analytes are within the calibration range.

10.6.4. Collate the reportable raw data separating the QC results from the sample results.

10.6.5. Keep all other data generated with the analytical folder marked with “For record only”.

10.7. **Report Generation**

10.7.1. Generate the method.txt file using WBD1C.exe.

10.7.2. Generate the sample results using F1NV3C.exe.

10.7.3. Generate the QC summary using QCV3CN.exe.

10.7.4. Generate the Instrument Performance Check (ICAL and DCC) using F5VOA.exe.

10.7.5. Generate the IS and RT summary using F882603.exe.

10.7.6. Generate Lab Chronicle using LABCHRN1.exe

10.7.7. Generate Case Narrative using CN1.exe

10.8. **Data Review**

10.8.1. Arrange the analysis package in sequence as detailed below using section separators. Attach all raw data to every form generated, to include manual integration and re-analyses.

- Case Narrative
- Lab Chronicle
- Sample Results
- Method Blank Results
- LCS/LCSD Summary
- MS/MSD Summary
- Instrument Performance Check (ICAL)
- ICAL Summary
- ICV Summary
- Instrument Performance Check (DCC)
- IS and RT Summary
- DCC Summary
- Analytical Run Log
- Sample Preparation Log
- Non-Conformance Report (If any)

10.8.2. Perform a 100% data review in accordance to EMAX-DM01and the PSR.

- Check internal standard area. They should be within -50 to +100% of ICAL midpoint to be acceptable, otherwise follow PSR.

- Check retention time of each IS to the ICAL midpoint. They should be within ± 30 seconds to be acceptable, otherwise follow PSR.
- Check surrogate recoveries against project specific criteria (PSR). In the absence of PSR, default to in-house QC limits.
- Check concentration of target analytes if calibration range is exceeded.
- If any of the above checkpoints indicate a problem, re-analysis is required.

10.8.3. Review the case narrative and check that it accurately describes what transpired in the analytical process. Edit as necessary to reflect essential issues not captured by the case narrative generator program.

10.8.4. Submit the analytical folder for secondary review.

10.9. **Preventive Maintenance**

10.9.1. Perform instrument routine preventive maintenance and record on instrument-specific maintenance logs. Routine maintenance ensures that all equipment is operating under optimum conditions, thus reducing the possibility of instrument malfunction that may affect data quality.

10.9.2. The table below list suggested routine maintenance schedule.

Task	**Every Day**	**Every Week**	**Every Month**	**Every 3 Months**	**Every 6 Months**	**As Needed**
Tune Check	✓					
Check gas cylinders pressure	✓					
Check the foreline pump oil level		✓				
Check the calibration vial						✓
Check and if necessary, change injection port liners, septa and O-rings.					✓	
Replace the foreline pump oil					✓	
Replace the diffusion pump fluid					✓	
Replace the traps and filters					✓	
Clean the ion source						✓
Change the carrier gas trap(s) and purifier						✓
Replace column						✓
AutoTune the MSD						✓
Replace the worn out parts						✓

11.0 QUALITY CONTROL

11.1. **Sample Preparation Batch QC**

11.1.1. Analyze Method Blank (MB) to demonstrate that preparation of samples was free from contamination.

11.1.2. Analyze Lab Control Sample (LCS/LCD) to assess preparative batch accuracy and precision.

11.1.3. Analyze Matrix Spike (MS/MSD) to assess matrix interference.

11.1.4. All lab wares used in the sample preparation shall be properly treated as specified in EMAX-QC07.

11.1.5. All solvents and reagents shall undergo quality control check in the stationary laboratory prior to its use.

- Verify that the spike amount added is accurate by checking the record.
- If LCS is within acceptance criteria and the right amount of spike is added into the sample then it is indicative of matrix interference. Discuss the probable matrix interference in the case narrative.

11.2. **Analytical Batch QC**

11.2.1. Perform tune check to verify that the mass spectrometer meets standard mass spectra abundance criteria prior to calibration and check for any contamination.

11.2.2. Perform initial calibration (ICAL) to establish a calibration curve for the quantification of the analytes of interest.

11.2.3. Establish retention time window position for each analyte every after ICAL for proper qualitative identification.

11.2.4. Perform initial continuing calibration verification (ICV) every after ICAL to verify accuracy of ICAL.

11.2.5. Perform continuing calibration verification (CCV) every 12 hours to verify that instrument response is reliable, and has not changed significantly from the current ICAL curve.

11.2.6. Evaluate relative retention time for each analytes in every sample to be within ± 0.06 RRT units.

11.2.7. Verify internal standards(IS) for quantitative accuracy and that its Retention time is within ± 30 seconds from retention time of the midpoint standard in the ICAL and EICP area is within -50% to +100% of ICAL midpoint standard.

11.2.8. Evaluate surrogate recovery to monitor instrument response on every sample.

11.3. **Method QC**

11.3.1. Establish detection limit (DL) to determine the smallest analyte concentration that can be demonstrated to be different from zero.

11.3.2. Establish limit of detection (LOD) to determine the smallest concentration of an analyte that can be qualitatively identified in a sample with 99% confidence level.

11.3.3. Establish limit of quantitation (LOQ) to determine the lowest concentration that produces a quantitative result within specified limits of precision and bias.

11.3.4. All analysts conducting this analysis must have an established Demonstration of Capability (DOC) as described in EMAX-QA05.

11.4. Refer to Appendix 1 for all related Quality Control parameters, frequency, acceptance criteria and corrective action

12.0 CORRECTIVE ACTION

12.1. Sample Preparation QC

12.1.1. If MB is non-compliant, consider the following suggestions to correct the problem:

- If contaminant is trace level, bake the trap at 260°C for about 30 minutes.
- If contamination is high, flush the sample line with methanol and replace the trap.
- If problem persist, inform the supervisor for further advice.

12.1.2. LCS is non-compliant, consider the following suggestions to help you correct the problem:

- If result is bias low or high, prepare a fresh standard and re-analyze LCS and the associated samples.
- If problem persist, inform the supervisor for further advice.

12.1.3. If MS is non-compliant consider the following suggestion to correct the problem:

- Verify that the spike amount added is accurate by checking the record and the micropipette calibration.
- If LCS is within acceptance criteria then and the right amount of spike is added into the sample then it is indicative of matrix interference. Discuss the probable matrix interference in the case narrative.

12.2. Analytical Batch QC

12.2.1. Tune Check. If tune check is non-compliant consider the following suggestion to correct the problem:

- Check the abundance of mass 95 and 174. If it is significantly less than previous tune checks, it is indicative of insufficient amount of BFB injected. Probable causes are: improper spiking, leaks, standard degradation or low vacuum system. Repeat tune check ensuring that BFB was properly spiked or rule out leaks, prepare a fresh BFB standard and repeat the tune check.
- If problem persist, re-tune the instrument and repeat tune check.
- If problem persist, inform the supervisor for further action.

12.2.2. Initial Calibration

12.2.2.1. If the %RSD is out of acceptance criteria, consider the following suggestions to correct the problem.

- If one of the standards returns a bias low or bias high on all of the analytes then that point is considered an out-liner. Prepare a standard at that ICAL point and re-analyze.
- If the highest ICAL point appears to be saturated, drop the highest point.
- If the lowest point returns a bias low or bias high response or the peaks are not

distinct and sharp, drop the lowest point.

Note : The lowest calibration point identifies the limit of quantitation (LOQ). Therefore, check that the LOQ is in conformance to the current projects where the ICAL will be used.

12.2.2.2. If instrument problem is suspected consider the following suggestion to correct the problem:

- Check the connection and make sure they are air tight and perform maintenance as needed.
- Check the gas flow.
- Re-tune the MS.
- Prepare a fresh standard and repeat calibration.
- Clean the MS source and repeat calibration.

12.2.3. Initial Calibration Verification (ICV). If the ICV is non-compliant, consider the following suggestions to correct the problem:

- Re-analyze ICV to rule out poor purge.
- If ICV is still out of acceptance criteria, prepare a fresh standard and re-analyze to rule out any preparation error.
- If ICV is still out of acceptance criteria, prepare a fresh ICAL standard and repeat calibration.
- If problem persist, inform the supervisor for further action.

12.2.4. Daily Calibration Check (DCC). If DCC is non-compliant consider the following suggestions to correct the problem:

- If majority of the analyte response are low and no evidence of leak in the system is apparent, it is indicative of a bad purge or leak in the vial. Re-analyze DCC.
- If problem persist, rule out standard degradation. Prepare a fresh standard and repeat DCC.
- Otherwise execute instrument maintenance and perform ICAL.

12.2.5. Instrument Blank. If instrument blank is non-compliant, consider the following suggestions to correct the problem:

- If contaminant is trace level, bake the trap at 260°C for about 30 minutes.
- If contamination is high, flush the sample line with methanol and replace the trap.
- If problem persist, inform the supervisor for further action.

12.3. Generate a Non-Conformance Report (NCR) when an anomaly other than specified in Appendix 1 is observed. Refer to EMAX-QA08 for NCR details.

ADD 12.4. Discuss water samples that are labeled preserved having a pH value > 2 in the case narrative.

13.0 POLLUTION PREVENTION

13.1. Observe all necessary precautions to avoid spillage of solvent that may go to wastewater drains.

13.2. Prepare all standards in fume hoods.

13.3. All unused samples shall be endorsed to the Waste Disposal Unit (WDU) for proper disposal. No samples shall be dumped on the laboratory sink.

13.4. Separate and properly identify all unused expired analytical standards for proper disposal.

14.0 WASTE MANAGEMENT

14.1. Practice the "Less is Better" strategies when preparing for analytical standards. This will minimize the production of surplus chemical wastes.

14.2. Dispose all unused samples, expired analytical standards and other waste generated during the analytical process in accordance to EMAX-SM03.

15.0 SUPPLEMENTARY NOTES

15.1. **Definition of Terms**

15.1.1. Analyte – The specific chemicals or components for which a sample is analyzed; may be a group of chemicals that belong to the same chemical family, and which are analyzed together.

15.1.2. Batch – is a group of samples that are prepared and/or analyzed at the same time using the same lot of reagents.

15.1.2.1. **Preparation Batch** - is composed of one to 20 samples of the same matrix, a method blank, a lab control sample and matrix spike/matrix spike duplicate.

15.1.2.2. **Analytical batch -** is composed of prepared samples (extracts, digestates, or concentrates), which are analyzed together as a group using an instrument in conformance to the analytical requirement. An analytical batch can include samples originating from various matrices, preparation batches, and can exceed 20 samples.

15.1.3. Detection Limit (DL) – The lowest concentration or amount of the target analyte that can be identified, measured and reported with confidence that the analyte concentration is not a false positive.

15.1.4. Limit of Detection (LOD) – An estimate of the minimum amount of substance that an analytical process can reliably detect.

15.1.5. Limit of Quantitation (LOQ) – The minimum levels, concentrations or quantities of target variable (e.g., target analyte) that can be reported with a specified degree of confidence.

15.1.6. Material Safety Data Sheet (MSDS) – is where the physical data, toxicology and safety precaution of a certain substance is listed.

15.1.7. Calibration – is a determinant measured from a standard to obtain the correct value of an instrument output.

15.1.8. Carry-over – are contaminants retained in the instrument/apparatus from a highly contaminated sample that is passed into the succeeding sample(s).

15.1.9. Calibration Check Compounds (CCC) – evaluate the integrity of the system. Variability of these compounds may indicate system leak or reactive sites in the column.

15.1.10. Instrument Method – is a file generated to contain the instrument calibration and instrument parameter settings for a particular analysis.

15.1.11. Instrument Blank – is a target-analyte-free solvent subjected to the entire analytical process to establish zero baseline or background value.

15.1.12. Method Blank – is a target-analyte-free sample subjected to the entire sample preparation and/or analytical to monitor contamination.

15.1.13. Lab Control Sample (LCS) – is a target-analyte-free sample spiked with a verified known amount of target analyte(s) or a reference material with a certified known value subjected to the entire sample preparation and/or analytical process. LCS is analyzed to monitor the accuracy of the analytical system.

15.1.14. Lab Control Sample Duplicate (LCSD) – is a replicate of LCS analyzed to monitor precision in the absence of MS/MSD sample.

15.1.15. Sample – is a specimen received in the laboratory bearing a sample label traceable to the accompanying COC. Samples collected in different containers having the same field sample ID are considered the same and therefore labeled with the same lab sample ID unless otherwise specified by the project.

15.1.16. Sample Duplicate – is a replicate of a sub-sample taken from one sample, prepared and analyzed within the same preparation batch.

15.1.17. Sub-sample – is an aliquot taken from a sample for analysis. Each sub-sample is uniquely identified by the sample preparation ID.

15.1.18. Matrix – is a component or form of a sample.

15.1.19. Matrix Spike (MS) – is a sample spiked with a verified known amount of target analyte(s) subjected to the entire sample preparation and/or analytical process. MS is analyzed to monitor matrix effect on a method's recovery efficiency.

15.1.20. Matrix Spike Duplicate (MSD) – is a replicate of MS analyzed to monitor precision or recovery.

15.1.21. Re-analysis – is a repeated analysis from the same extract/digestate or sample, identified with the Lab Sample ID suffixed with "W".

15.1.22. Re-extract/digest – is a repeated sample preparation process identified with the Lab Sample ID suffixed with "R".

15.1.23. Response Factor – is the ratio of the peak area of the target compound in the sample or sample extract.

15.1.24. Surrogate – are compounds added to every blank, sample, matrix spike, matrix spike duplicate and standard; used to evaluate analytical efficiency by measuring recovery. Compounds not expected to be detected in environmental media.

15.1.25. SPCC – System performance check compounds are compounds that are used to check compound stability and to check for degradation cause by contaminated lines or active sites in the system.

15.2. **Application of EMAX QC Procedures**

15.2.1. The procedures and QC criteria summarized in this SOP shall be applied to all projects when performing Volatile analysis by GC/MS. The standard analyte list and RL are presented in Tables 7 & 8. In instances where there is a project or program QAPP, the requirements given in the project shall take precedence over this SOP.

15.3. **Department of Defense (DoD) Projects**

15.3.1. Samples from DoD sponsored projects shall follow the Quality Assurance Project Plan (QAPP), Statement of Work (SOW) and/or client's quality control directive. In the absence of QAPP, the DoD Quality Systems Manual (QSM), latest update, shall be applied

15.4. **Department of Energy Basic Ordering Agreement (DOE-BOA) Projects**

15.4.1. Samples from DoE sponsored projects shall follow the Quality Assurance Project Plan (QAPP), Statement of Work (SOW) and/or client's quality control directive. In the absence of QAPP, the DoE Quality Systems for Analytical Services (QSAS), latest update, shall be applied.

16.0 REFERENCES

16.1. U.S. EPA Method 8260B; SW846, as updated.

16.2. EMAX Quality Systems Manual, as updated.

17.0 APPENDICES

17.1. **Tables**

17.1.1.	Table 1	Initial Calibration Intermediate Standard Preparation
17.1.2.	Table 2	Initial Calibration Verification/LCS/MS/MSD Intermediate Standard Preparation
17.1.3.	Table 3	Surrogate/Internal Standards Preparation
17.1.4.	Table 4	Tuning Solution Standard Preparation
17.1.5.	Table 5	Typical Initial Calibration and QC Standards Concentration Levels for 5 ml
17.1.6.	Table 5a	Typical Initial Calibration and QC Standards Concentration Levels for 25 ml
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17.1.9.	Table 8	Characteristic Ions for Purgeable Organic Compounds
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17.2. **Figures**

17.2.1.	Figure 1	Peak Evaluation Techniques
17.2.2.	Figure 2	Typical Chromatogram for 5 ml
17.2.3.	Figure 2a	Typical Chromatogram for 25 ml
16.1.1.	Figure 3	Typical ICAL Summary for 5 ml

16.1.2. Figure 3a Typical ICAL Summary for 25 ml

16.1.3. Figure 4 Typical Instrument Performance Check (Tuning)

16.1.4. Figure 4a Typical Instrument Performance Check (Tuning) Summary

16.1.5. Figure 5 Typical Internal Standard Area and Retention Time Summary

16.1.6. Figure 6 Typical Sample Result Summary

16.1.7. Figure 7 Typical LCS/LCSD Report Summary

16.1.8. Figure 8 Typical MS/MSD Report Summary

16.1.9. Figure 9 Typical Case Narrative

17.3. **Appendices**

17.3.1. Appendix 1 Summary of Quality Control Procedures

17.3.2. Appendix 2 Demonstration of Capability for 5 ml

17.3.3. Appendix 3 Demonstration of Capability for 25 ml

17.4. **Forms**

17.4.1. 8260FA Analytical Run Log

17.4.2. 8260FM Instrument Maintenance Log

Table 1: INITIAL CALIBRATION INTERMEDIATE STANDARD PREPARATION

ICAL/DCC Intermediate Standard	Stock Standard			Preparation (Solvent: Methanol)		Final Conc. (mg/L)
	Standard Name	Source	Conc. (mg/L)	Aliquot (µl)	Final Vol. (ml)	
I	1-Chlorohexane	AccuStandard	2000	50	2	50
	2-Chloroethylvinylether	CPI	2000	50	2	50
	Oxygenate Gasoline Additive	AccuStandard	2000-10000	50	2	50 - 250
	Custom VOA Mix	CPI	2000, 20000, 40000	50	2	50, 500, 1000
II	VOC Gas Mix	Ultra Scientific	2000	250	2	250
	Vinyl Acetate	CPI	2500	200	2	250
III	Carbon Disulfide	CPI	5000	100	2	250
IV	VOA Calibration Mix 1	Restek	5000	100	2	250
	Acrolein / Acrylonitrile	AccuStandard	5000	100	2	250

Table 2: INITIAL CALIBRATION VERIFICATION/LCS/MS/MSD INTERMEDIATE STANDARD PREPARATION

ICV / LCS / MS Intermediate Standard	Stock Standard			Preparation (Solvent: Methanol)		Final Conc. (mg/L)
	Standard Name	Source	Conc. (mg/L)	Aliquot (µl)	Final Vol. (ml)	
I	1-Chlorohexane	Ultra Scientific	1000	100	2	50
	2-Chloroethylvinylether	AccuStandard	2000	50	2	50
	California Oxygenate Mix	Restek	2000 - 10000	50	2	50 – 250
	Custom 8260 Mega Mix	Restek	2000, 20000, 40000	50	2	50, 500, 1000
II	Volatile Organic Cpds Mix 6	Supelco	2000	250	2	250
	Vinyl Acetate	Restek	2000	250	2	250
III	Carbon Disulfide Solution	Ultra scientific	5000	20	2	50
IV	TCL Volatile Mix 1	Supelco	2000	250	2	250
	Acrolein / Acrylonitrile	Ultra Scientific	2000	250	2	250

Table 3: SURROGATE / INTERNAL STANDARD PREPARATION

Intermediate Standard	Stock Standard			Preparation (Solvent: Methanol)		Final Conc. (mg/L)
	Standard Name	Source	Conc. (mg/L)	Aliquot (µl)	Final Vol. (ml)	
Surrogate	8260 Surrogate Mix	Restek	2500	200	2	250
Internal Standard	Custom 8260 Internal Standard Mix, 3-30	CPI	2500	200	2	250

Table 4: TUNING SOLUTION TANDARD PREPARATION

BFB Intermediate Standard	Stock Standard			Preparation (Solvent: Methanol)		Final Conc. (mg/L)
	Standard Name	Source	Conc. (mg/L)	Aliquot (µl)	Final Vol. (ml)	
Tuning Compound	BFB	Restek	5000	20	2	50

Table 5: TYPICAL INITIAL CALIBRATION AND QC STANDARDS CONCENTRATION LEVELS FOR 5 ml

Analytes	ICAL ANALYTE CONCENTRATIONS (µg/L) 5 ml Purge								ICV/ DCC	LCS/ MS
	1	2	3	4	5	6	7	8		
1,1,1,2-Tetrachloroethane	2	5	10	20	50	80	100	200	50	50
1,1,1-Trichloroethane	2	5	10	20	50	80	100	200	50	50
1,1,2,2-Tetrachloroethane	2	5	10	20	50	80	100	200	50	50
1,1,2-Trichloro-1,2,2-trifluoroethane	2	5	10	20	50	80	100	200	50	50
1,1,2-Trichloroethane	2	5	10	20	50	80	100	200	50	50
1,1-Dichloroethane	2	5	10	20	50	80	100	200	50	50
1,1-Dichloroethene	2	5	10	20	50	80	100	200	50	50
1,1-Dichloropropene	2	5	10	20	50	80	100	200	50	50
1,2,3-Trichlorobenzene	2	5	10	20	50	80	100	200	50	50
1,2,3-Trichloropropane	2	5	10	20	50	80	100	200	50	50
1,2,4-Trichlorobenzene	2	5	10	20	50	80	100	200	50	50
1,2,4-Trimethylbenzene	2	5	10	20	50	80	100	200	50	50
1,2-Dibromo-3-chloropropane	2	5	10	20	50	80	100	200	50	50
1,2-Dibromoethane	2	5	10	20	50	80	100	200	50	50
1,2-Dichlorobenzene	2	5	10	20	50	80	100	200	50	50
1,2-Dichloroethane	2	5	10	20	50	80	100	200	50	50
1,2-Dichloropropane	2	5	10	20	50	80	100	200	50	50
1,3,5-Trimethylbenzene	2	5	10	20	50	80	100	200	50	50
1,3-Dichlorobenzene	2	5	10	20	50	80	100	200	50	50
1,3-Dichloropropane	2	5	10	20	50	80	100	200	50	50
1,4-Dichlorobenzene	2	5	10	20	50	80	100	200	50	50
1-Chlorohexane	2	5	10	20	50	80	100	200	50	50
2,2-Dichloropropane	2	5	10	20	50	80	100	200	50	50
2-Butanone (MEK)	10	25	50	100	250	400	500	1000	250	250
2-Chloroethyl vinyl ether	2	5	10	20	50	80	100	200	50	50
2-Chlorotoluene	2	5	10	20	50	80	100	200	50	50
2-Hexanone	10	25	50	100	250	400	500	1000	250	250
4-Chlorotoluene	2	5	10	20	50	80	100	200	50	50
4-Methyl-2-pentanone (MIBK)	10	25	50	100	250	400	500	1000	250	250
Acetone	10	25	50	100	250	400	500	1000	250	250
Acrolein	10	25	50	100	250	400	500	1000	250	250
Acrylonitrile	10	25	50	100	250	400	500	1000	250	250
Benzene	2	5	10	20	50	80	100	200	50	50
Bromobenzene	2	5	10	20	50	80	100	200	50	50
Bromochloromethane	2	5	10	20	50	80	100	200	50	50
Bromodichloromethane	2	5	10	20	50	80	100	200	50	50
Bromoform	2	5	10	20	50	80	100	200	50	50
Bromomethane	2	5	10	20	50	80	100	200	50	50
Carbon disulfide	2	5	10	20	50	80	100	200	50	50
Carbon tetrachloride	2	5	10	20	50	80	100	200	50	50
Chlorobenzene	2	5	10	20	50	80	100	200	50	50
Chloroethane	2	5	10	20	50	80	100	200	50	50
Chloroform	2	5	10	20	50	80	100	200	50	50
Chloromethane	2	5	10	20	50	80	100	200	50	50
cis-1,2-Dichloroethene	2	5	10	20	50	80	100	200	50	50
cis-1,3-Dichloropropene	2	5	10	20	50	80	100	200	50	50
Dibromofluoromethane	2	5	10	20	50	80	100	200	50	50

Table 5: TYPICAL INITIAL CALIBRATION AND QC STANDARDS CONCENTRATION LEVELS FOR 5 ml

Analytes	ICAL ANALYTE CONCENTRATIONS (µg/L) 5 ml Purge								ICV/ DCC	LCS/ MS
	1	2	3	4	5	6	7	8		
Dibromochloromethane	2	5	10	20	50	80	100	200	50	50
Dibromomethane	2	5	10	20	50	80	100	200	50	50
Dichlorodifluoromethane	2	5	10	20	50	80	100	200	50	50
Dichlorofluoromethane	2	5	10	20	50	80	100	200	50	50
Diisopropyl ether (DIPE)	2	5	10	20	50	80	100	200	50	50
Ethyl Methacrylate	2	5	10	20	50	80	100	200	50	50
Ethylbenzene	2	5	10	20	50	80	100	200	50	50
Ethyl-tert-butyl ether (ETBE)	2	5	10	20	50	80	100	200	50	50
Hexachlorobutadiene	2	5	10	20	50	80	100	200	50	50
Iodomethane	2	5	10	20	50	80	100	200	50	50
Isopropylbenzene	2	5	10	20	50	80	100	200	50	50
m/p-Xylene	4	10	20	40	100	160	200	400	100	100
Methylene chloride	2	5	10	20	50	80	100	200	50	50
Methyl-t-butyl ether (MTBE)	2	5	10	20	50	80	100	200	50	50
Naphthalene	2	5	10	20	50	80	100	200	50	50
n-Butylbenzene	2	5	10	20	50	80	100	200	50	50
n-Propylbenzene	2	5	10	20	50	80	100	200	50	50
o-Xylene	2	5	10	20	50	80	100	200	50	50
p-Isopropyltoluene	2	5	10	20	50	80	100	200	50	50
sec-Butylbenzene	2	5	10	20	50	80	100	200	50	50
Styrene	2	5	10	20	50	80	100	200	50	50
tert-Amylmethyl ether (TAME)	2	5	10	20	50	80	100	200	50	50
tert-Butanol	10	25	50	100	250	400	500	1000	250	250
tert-Butylbenzene	2	5	10	20	50	80	100	200	50	50
Tetrachloroethene	2	5	10	20	50	80	100	200	50	50
Toluene	2	5	10	20	50	80	100	200	50	50
trans-1,2-Dichloroethene	2	5	10	20	50	80	100	200	50	50
trans-1,3-Dichloropropene	2	5	10	20	50	80	100	200	50	50
trans-1,4-Dichloro-2-butene	2	5	10	20	50	80	100	200	50	50
Trichloroethene	2	5	10	20	50	80	100	200	50	50
Trichlorofluoromethane	2	5	10	20	50	80	100	200	50	50
Vinyl acetate	2	5	10	20	50	80	100	200	50	50
Vinyl chloride	2	5	10	20	50	80	100	200	50	50
1,2-Dichloroethane-d4	2	5	10	20	50	80	100	200	50	50
Bromofluorobenzene	2	5	10	20	50	80	100	200	50	50
Toluene-D8	2	5	10	20	50	80	100	200	50	50

Table 5a: TYPICAL INITIAL CALIBRATION AND QC STANDARDS CONCENTRATION LEVELS FOR 25 ml

Analytes	ICAL ANALYTE CONCENTRATIONS (µg/L) 25 ml Purge									ICV/ DCC	LCS/ MS
	1	2	3	4	5	6	7	8	9		
1,1,1,2-Tetrachloroethane	0.3	0.5	1	2	5	10	20	30	40	10	10
1,1,1-Trichloroethane	0.3	0.5	1	2	5	10	20	30	40	10	10
1,1,2,2-Tetrachloroethane	0.3	0.5	1	2	5	10	20	30	40	10	10
1,1,2-Trichloro-1,2,2-trifluoroethane	0.3	0.5	1	2	5	10	20	30	40	10	10
1,1,2-Trichloroethane	0.3	0.5	1	2	5	10	20	30	40	10	10
1,1-Dichloroethane	0.3	0.5	1	2	5	10	20	30	40	10	10
1,1-Dichloroethene	0.3	0.5	1	2	5	10	20	30	40	10	10
1,1-Dichloropropene	0.3	0.5	1	2	5	10	20	30	40	10	10
1,2,3-Trichlorobenzene	0.3	0.5	1	2	5	10	20	30	40	10	10
1,2,3-Trichloropropane	0.3	0.5	1	2	5	10	20	30	40	10	10
1,2,4-Trichlorobenzene	0.3	0.5	1	2	5	10	20	30	40	10	10
1,2,4-Trimethylbenzene	0.3	0.5	1	2	5	10	20	30	40	10	10
1,2-Dibromo-3-chloropropane	0.3	0.5	1	2	5	10	20	30	40	10	10
1,2-Dibromoethane	0.3	0.5	1	2	5	10	20	30	40	10	10
1,2-Dichlorobenzene	0.3	0.5	1	2	5	10	20	30	40	10	10
1,2-Dichloroethane	0.3	0.5	1	2	5	10	20	30	40	10	10
1,2-Dichloropropane	0.3	0.5	1	2	5	10	20	30	40	10	10
1,3,5-Trimethylbenzene	0.3	0.5	1	2	5	10	20	30	40	10	10
1,3-Dichlorobenzene	0.3	0.5	1	2	5	10	20	30	40	10	10
1,3-Dichloropropane	0.3	0.5	1	2	5	10	20	30	40	10	10
1,4-Dichlorobenzene	0.3	0.5	1	2	5	10	20	30	40	10	10
1-Chlorohexane	0.3	0.5	1	2	5	10	20	30	40	10	10
2,2-Dichloropropane	0.3	0.5	1	2	5	10	20	30	40	10	10
2-Butanone (MEK)	1.5	2.5	5	10	25	50	100	150	200	50	50
2-Chloroethyl vinyl ether	0.3	0.5	1	2	5	10	20	30	40	10	10
2-Chlorotoluene	0.3	0.5	1	2	5	10	20	30	40	10	10
2-Hexanone	1.5	2.5	5	10	25	50	100	150	200	50	50
4-Chlorotoluene	0.3	0.5	1	2	5	10	20	30	40	10	10
4-Methyl-2-pentanone (MIBK)	1.5	2.5	5	10	25	50	100	150	200	50	50
Acetone	1.5	2.5	5	10	25	50	100	150	200	50	50
Acrolein	1.5	2.5	5	10	25	50	100	150	200	50	50
Acrylonitrile	1.5	2.5	5	10	25	50	100	150	200	50	50
Benzene	0.3	0.5	1	2	5	10	20	30	40	10	10
Bromobenzene	0.3	0.5	1	2	5	10	20	30	40	10	10
Bromochloromethane	0.3	0.5	1	2	5	10	20	30	40	10	10
Bromodichloromethane	0.3	0.5	1	2	5	10	20	30	40	10	10
Bromoform	0.3	0.5	1	2	5	10	20	30	40	10	10
Bromomethane	0.3	0.5	1	2	5	10	20	30	40	10	10
Carbon disulfide	0.3	0.5	1	2	5	10	20	30	40	10	10
Carbon tetrachloride	0.3	0.5	1	2	5	10	20	30	40	10	10
Chlorobenzene	0.3	0.5	1	2	5	10	20	30	40	10	10
Chloroethane	0.3	0.5	1	2	5	10	20	30	40	10	10
Chloroform	0.3	0.5	1	2	5	10	20	30	40	10	10
Chloromethane	0.3	0.5	1	2	5	10	20	30	40	10	10
cis-1,2-Dichloroethene	0.3	0.5	1	2	5	10	20	30	40	10	10
cis-1,3-Dichloropropene	0.3	0.5	1	2	5	10	20	30	40	10	10
Dibromofluoromethane	0.3	0.5	1	2	5	10	20	30	40	10	10

Table 5a: TYPICAL INITIAL CALIBRATION AND QC STANDARDS CONCENTRATION LEVELS FOR 25 ml

Analytes	ICAL ANALYTE CONCENTRATIONS (µg/L) 25 ml Purge									ICV/ DCC	LCS/ MS
	1	2	3	4	5	6	7	8	9		
Dibromochloromethane	0.3	0.5	1	2	5	10	20	30	40	10	10
Dibromomethane	0.3	0.5	1	2	5	10	20	30	40	10	10
Dichlorodifluoromethane	0.3	0.5	1	2	5	10	20	30	40	10	10
Dichlorofluoromethane	0.3	0.5	1	2	5	10	20	30	40	10	10
Diisopropyl ether (DIPE)	0.3	0.5	1	2	5	10	20	30	40	10	10
Ethyl Methacrylate	0.3	0.5	1	2	5	10	20	30	40	10	10
Ethylbenzene	0.3	0.5	1	2	5	10	20	30	40	10	10
Ethyl-tert-butyl ether (ETBE)	0.3	0.5	1	2	5	10	20	30	40	10	10
Hexachlorobutadiene	0.3	0.5	1	2	5	10	20	30	40	10	10
Iodomethane	0.3	0.5	1	2	5	10	20	30	40	10	10
Isopropylbenzene	0.3	0.5	1	2	5	10	20	30	40	10	10
m/p-Xylene	0.6	1	2	4	10	20	40	60	80	20	20
Methylene chloride	0.3	0.5	1	2	5	10	20	30	40	10	10
Methyl-t-butyl ether (MTBE)	0.3	0.5	1	2	5	10	20	30	40	10	10
Naphthalene	0.3	0.5	1	2	5	10	20	30	40	10	10
n-Butylbenzene	0.3	0.5	1	2	5	10	20	30	40	10	10
n-Propylbenzene	0.3	0.5	1	2	5	10	20	30	40	10	10
o-Xylene	0.3	0.5	1	2	5	10	20	30	40	10	10
p-Isopropyltoluene	0.3	0.5	1	2	5	10	20	30	40	10	10
sec-Butylbenzene	0.3	0.5	1	2	5	10	20	30	40	10	10
Styrene	0.3	0.5	1	2	5	10	20	30	40	10	10
tert-Amylmethyl ether (TAME)	0.3	0.5	1	2	5	10	20	30	40	10	10
tert-Butanol	1.5	2	5	10	25	50	100	150	200	50	50
tert-Butylbenzene	0.3	0.5	1	2	5	10	20	30	40	10	10
Tetrachloroethene	0.3	0.5	1	2	5	10	20	30	40	10	10
Toluene	0.3	0.5	1	2	5	10	20	30	40	10	10
trans-1,2-Dichloroethene	0.3	0.5	1	2	5	10	20	30	40	10	10
trans-1,3-Dichloropropene	0.3	0.5	1	2	5	10	20	30	40	10	10
trans-1,4-Dichloro-2-butene	0.3	0.5	1	2	5	10	20	30	40	10	10
Trichloroethene	0.3	0.5	1	2	5	10	20	30	40	10	10
Trichlorofluoromethane	0.3	0.5	1	2	5	10	20	30	40	10	10
Vinyl acetate	0.3	0.5	1	2	5	10	20	30	40	10	10
Vinyl chloride	0.3	0.5	1	2	5	10	20	30	40	10	10
1,2-Dichloroethane-d4	0.3	0.5	1	2	5	10	20	30	40	10	10
Bromofluorobenzene	0.3	0.5	1	2	5	10	20	30	40	10	10
Toluene-D8	0.3	0.5	1	2	5	10	20	30	40	10	10

Table 6: BFB KEY ION ABUNDANCE CRITERIA

M/z	Required Intensity (relative abundance)
50	15 to 40% of m/z 95
75	30 to 60% of m/z 95
95	Base peak, 100% relative abundance
96	5 to 9% of m/z 95
173	Less than 2% of m/z 174
174	Greater than 50% of m/z 95
175	5 to 9% of m/z 174
176	Greater than 95% but less than 101% of m/z 174
177	5 to 9% of m/z 176

Table 7: ESTABLISHED DL, LOD AND LOQ

Parameter	Water (5 ml purge) (µg/L)			Water (25 ml purge) (µg/L)			Soil (µg/Kg)		
	DL	LOD	LOQ	DL	LOD	LOQ	DL	LOD	LOQ
Acetone	2.5	5	10	2.6	5	10	3.06	5	10
Acrolein	2.5	5	10	2.5	5	10	2.5	5	10
Acrylonitrile	2.5	5	10	2.5	5	10	2.5	5	10
Benzene	0.5	1	5	0.1	0.2	0.5	0.5	1	5
Bromobenzene	0.5	1	5	0.1	0.2	0.5	0.5	1	5
Bromochloromethane	0.5	1	5	0.11	0.2	0.5	0.5	1	5
Bromodichloromethane	0.5	1	5	0.1	0.2	0.5	0.5	1	5
Bromoform	0.5	1	5	0.15	0.3	0.5	1	2	5
Bromomethane	1.1	2	5	0.16	0.3	0.5	1.81	2	5
tert-Butyl alcohol	7.1	10	25	2.5	5	10	9.18	10	20
2-Butanone (MEK)	2.5	5	10	2	4	10	2.5	5	10
n-Butylbenzene	0.73	1	5	0.17	0.2	0.5	0.7	1	5
sec-Butylbenzene	0.5	1	5	0.13	0.2	0.5	0.67	1	5
tert-Butylbenzene	0.5	1	5	0.13	0.2	0.5	0.62	1	5
Carbon disulfide	0.5	1	5	0.1	0.2	0.5	0.5	1	5
Carbon tetrachloride	0.5	1	5	0.1	0.2	0.5	0.54	1	5
Chlorobenzene	0.5	1	5	0.1	0.2	0.5	0.5	1	5
2-Chloroethyl vinyl ether	1	2	5	0.5	1	2	1	2	5
Chloroethane	1	2	5	0.27	0.3	0.5	1	2	5
Chloroform	0.5	1	5	0.1	0.2	0.5	0.5	1	5
1-Chlorohexane	0.5	1	5	0.14	0.2	0.5	0.58	1	5
Chloromethane	1	2	5	0.15	0.3	0.5	1.02	2	5
2-Chlorotoluene	0.5	1	5	0.12	0.2	0.5	0.82	1	5
4-Chlorotoluene	0.61	1	5	0.11	0.2	0.5	0.67	1	5
Dibromochloromethane	0.5	1	5	0.1	0.2	0.5	0.5	1	5
1,2-Dibromo-3-chloropropane	1	2	5	0.25	0.5	1	1	2	5
1,2-Dibromoethane	0.5	1	5	0.1	0.2	0.5	0.5	1	5
Dibromomethane	0.5	1	5	0.1	0.2	0.5	0.5	1	5
1,1-Dichloroethane	0.5	1	5	0.1	0.2	0.5	0.5	1	5
1,2-Dichloroethane	0.5	1	5	0.1	0.2	0.5	0.5	1	5
1,2-Dichlorobenzene	0.5	1	5	0.1	0.2	0.5	0.5	1	5
1,3-Dichlorobenzene	0.5	1	5	0.11	0.2	0.5	0.52	1	5
trans-1,4-Dichloro-2-Butene	1	2	5	0.5	1	2	1	2	5
1,4-Dichlorobenzene	0.5	1	5	0.1	0.2	0.5	0.5	1	5
Dichlorodifluoromethane	1.3	2	5	0.15	0.3	0.5	1.16	2	5
1,1-Dichloroethene	0.5	1	5	0.1	0.2	0.5	0.5	1	5
cis-1,2-Dichloroethene	0.5	1	5	0.1	0.2	0.5	0.5	1	5
trans-1,2-Dichloroethene	0.5	1	5	0.1	0.2	0.5	0.5	1	5
Dichlorofluoromethane	0.5	1	5	0.1	0.2	0.5	0.5	1	5
1,1-Dichloropropene	0.5	1	5	0.1	0.2	0.5	0.5	1	5
1,2-Dichloropropane	0.5	1	5	0.1	0.2	0.5	0.5	1	5
1,3-Dichloropropane	0.5	1	5	0.1	0.2	0.5	0.5	1	5
2,2-Dichloropropane	1	2	5	0.16	0.2	0.5	1	2	5
cis-1,3-Dichloropropene	0.5	1	5	0.1	0.2	0.5	0.5	1	5
trans-1,3-Dichloropropene	0.5	1	5	0.11	0.2	0.5	0.5	1	5
tert-Butyl ethyl ether (ETBE)	0.5	1	5	0.11	0.2	0.5	0.5	1	5

Table 7: ESTABLISHED DL, LOD AND LOQ

Parameter	Water (5 ml purge) (µg/L)			Water (25 ml purge) (µg/L)			Soil (µg/Kg)		
	DL	LOD	LOQ	DL	LOD	LOQ	DL	LOD	LOQ
Ethyl Methacrylate	1	2	5	0.25	0.5	1	1	2	5
Ethybenzene	0.5	1	5	0.1	0.2	0.5	0.5	1	5
2-Hexanone (MBK)	2.5	5	10	2.3	4	5	2.86	5	10
Hexachlorobutadiene	0.5	1	5	0.22	0.3	0.5	1	2	5
Iodomethane	0.5	1	5	0.15	0.3	0.5	1	2	5
Isopropyl ether (DIPE)	0.5	1	5	0.11	0.2	0.5	0.5	1	5
Isopropylbenzene	0.5	1	5	0.1	0.2	0.5	0.64	1	5
p-Isopropyltoluene	0.56	1	5	0.14	0.2	0.5	0.62	1	5
Methylene Chloride	0.5	1	5	0.25	0.5	1	1	2	5
4-Methyl-2-pentanone (MIBK)	2.5	5	10	2.2	4	5	2.75	5	10
Tert-Butyl methyl ether	0.5	1	5	0.13	0.2	0.5	0.5	1	5
Naphthalene	1	2	5	0.25	0.5	1	1	2	5
n-Propylbenzene	0.51	1	5	0.13	0.2	0.5	0.65	1	5
Styrene	0.5	1	5	0.1	0.2	0.5	0.5	1	5
tert-Amyl methyl ether (TAME)	0.5	1	5	0.11	0.2	0.5	0.5	1	5
1,1,1,2-Tetrachloroethane	0.5	1	5	0.1	0.2	0.5	0.5	1	5
1,1,2,2-Tetrachloroethane	0.5	1	5	0.11	0.2	0.5	0.5	1	5
Tetrachloroethene	0.52	1	5	0.15	0.2	0.5	0.5	1	5
Toluene	0.5	1	5	0.1	0.2	0.5	0.5	1	5
1,1,1-Trichloroethane	0.5	1	5	0.1	0.2	0.5	0.5	1	5
1,1,2-Trichloroethane	0.5	1	5	0.1	0.2	0.5	0.5	1	5
1,2,3-Trichlorobenzene	0.5	1	5	0.15	0.3	0.5	1	2	5
1,2,4-Trichlorobenzene	0.5	1	5	0.15	0.3	0.5	1	2	5
Trichloroethene	0.5	1	5	0.1	0.2	0.5	0.5	1	5
Trichlorofluoromethane	0.86	1	5	0.15	0.3	0.5	1.06	2	5
1,2,3-Trichloropropane	1	2	5	0.25	0.5	1	1	2	5
1,1,2-Trichloro-1,2,3-trifluoroethane	1	2	5	0.17	0.3	0.5	1	2	5
1,2,4-Trimethybenzene	0.5	1	5	0.11	0.2	0.5	0.55	1	5
1,3,5-Trimethybenzene	0.5	1	5	0.13	0.2	0.5	0.59	1	5
Vinyl Acetate	1	2	5	0.25	0.5	1	1.26	2	5
Vinyl Chloride	0.61	1	5	0.12	0.2	0.5	1	2	5
m-Xylene & p-xylene	1	2	10	0.21	0.4	1	1	2	10
o-xylene	0.5	1	5	0.1	0.2	0.5	0.5	1	5
1,2-Dichloroethane-d4	1	2	5	0.5	1	2	1	2	5
Toluene-d8	1	2	5	0.5	1	2	1	2	5
4-Bromofluorobenzene	1	2	5	0.5	1	2	1	2	5
Dibromofluoromethane	1	2	5	0.5	1	2	0.5	1	5

Table 8: CHARACTERISTIC IONS

ANALYTE	PRIMARY CHARACTERISTIC ION(S)	SECONDARY CHARACTERISTIC ION(S)
Acetone	43	58, 42
Acrolein	56	55
Acrylonitrile	53	52, 51
Benzene	78	77, 52
Bromobenzene	156	77, 158
Bromochloromethane	49	128, 130
Bromodichloromethane	83	85
Bromoform	173	171, 175
Bromomethane	94	96
tert-Butyl alcohol	59	41
2-Butanone (MEK)	43	72
n-Butylbenzene	91	92, 134
sec-Butylbenzene	105	134
tert-Butylbenzene	134	91, 119
Carbon Disulfide	76	78
Carbon Tetrachloride	119	117
Chlorobenzene	112	51, 77, 114
2-Chloroethyl vinyl ether	63	65, 106
Chloroethane	64	49, 66
Chloroform	83	85, 47
1-Chlorohexane	91	93, 55, 56
Chloromethane	50	52
2-Chlorotoluene	91	126
4-Chlorotoluene	91	126
Dibromochloromethane	129	127
1,2-Dibromo-3-chloropropane	157	155, 75
1,2-Dibromoethane	107	109
Dibromomethane	93	95, 174
1,1-Dichloroethane	63	65, 83
1,2-Dichloroethane	62	64
1,2-Dichlorobenzene	146	111, 148
1,3-Dichlorobenzene	146	111, 148
trans-1,4-Dichloro-2-butene	53	88
1,4-Dichlorobenzene	146	111, 148
Dichlorodifluoromethane	85	87
1,1-Dichloroethene	61	63, 96
cis-1,2-Dichloroethene	96	61, 98
trans-1,2-Dichloroethene	61	96, 98

Table 8: CHARACTERISTIC IONS

Dichlorofluoromethane	67	69
1,1-Dichloropropene[4]	110	112
1,2-Dichloropropane	63	41, 76
1,3-Dichloropropane	76	78
2,2-Dichloropropane	77	97, 79
cis-1,3-Dichloropropene	75	77, 39, 110
trans-1,3-Dichloropropene	75	77, 39
tert-Butyl ethyl ether (ETBE)	59	87
Ethyl Methacrylate	69	99, 41
Ethylbenzene	91	106
2-Hexanone (MBK)	43	58, 100
Hexachlorobutadiene	225	223, 227
Iodomethane	142	127
Isopropyl ether (DIPE)	45	87
Isopropylbenzene	105	120, 79, 103
p-Isopropyltoluene	119	91, 134
Methylene chloride	49	84, 86
4-Methyl-2-pentanone (MIBK)	43	58, 85, 100
Methyl-t-butyl ether (MTBE)	73	57
Naphthalene	128	127
n-Propylbenzene	91	65, 120
Styrene	104	78, 103
tert-Amyl methyl ether (TAME)	87	55,73
1,1,1,2-Tetrachloroethane	131	133, 119, 117
1,1,2,2-Tetrachloroethane	83	85
Tetrachloroethene	164	129, 131, 166
Toluene	91	92
1,1,1 -Trichloroethane	97	99, 61
1,1,2 -Trichloroethane	97	83, 85, 99
1,2,3-Trichlorobenzene	180	182, 145
1,2,4-Trichlorobenzene	180	182, 145
Trichloroethene	130	97, 132, 95
Trichlorofluoromethane	101	103
1,2,3-Trichloropropane	110	61, 77
1,1,2-Trichloro-1,2-2-trifluoroethane	151	153
1,2,4-Trimethylbenzene	105	120
1,3,5-Trimethylbenzene	105	120, 119
Vinyl acetate	43	86
Vinyl chloride	62	64
o-Xylene	91	106

[4] Quantitation ion was changed due to co-elution (1,1-Dichloropropene – 75 to 77)

Table 8: CHARACTERISTIC IONS

m-Xylene	91	106
p-Xylene	91	106
INTERNAL STANDARDS		
1,4-Difluorobenzene	114	88
Chlorobenzene-d5	117	82, 119
1,2-Dichlorobenzene-d4	152	150
SURROGATES		
1,2-Dichloroethane-d4	65	102
Toluene-d8	98	100
4-Bromofluorobenzene	95	174, 176
Dibromofluoromethane	111	113, 192

Table 9: INTERNAL STANDARDS WITH CORRESPONDING TARGET COMPOUNDS AND SURROGATES ASSIGNED FOR QUANTITATION

1,4-DIFLUOROBENZENE	**CHLOROBENZENE-D_5**	**1,2-DICHLOROBENZENE-D_4**
Acetone	Benzene	Bromobenzene
Acrolein	Bromodichloromethane	Bromoform
Acrylonitrile	Carbon Tetrachloride	n-Butylbenzene
Bromochloromethane	Chlorobenzene	sec-Butylbenzene
Bromomethane	2-Chloroethyl Vinyl Ether	tert-Butylbenzene
Tert-butanol	1-Chlorohexane	2-Chlorotoluene
2-Butanone (MEK)	Dibromochloromethane	4-Chlorotoluene
Carbon Disulfide	1,2-Dibromoethane	1,2-Dibromo-3-Chlorpropane
Chloroethane	Dibromomethane	1,2-Dichlorobenzene
Chloroform	1,2-Dichloroethane	1,3-Dichlorobenzene
Chloromethane	1,1-Dichloropropene	trans-1,4-Dichloro-2-butene
1,1-Dichloroethane	1,2-Dichloropropane	1,4-Dichlorobenzene
Dichlorodifluoromethane	1,3-Dichloropropane	Hexachlorobutadiene
1,1-Dichloroethene	cis-1,3-Dichloropropene	Isopropyl Benzene
cis-1,2-Dichloroethene	trans-1,3-Dichloropropene	p-Isopropyltoluene
trans-1,2-Dichloroethene	Ethyl Methacrylate	Naphthalene
Dichlorofluoromethane	Ethylbenzene	n-Propylbenzene
2,2-Dichloropropane	2-Hexanone (MBK)	1,1,2,2-Tetrachloroethane
tert-butyl ethyl ether (ETBE)	4-Methyl-2-Pentanone (MIBK)	1,2,3-Trichlorobenzene
Iodomethane	Styrene	1,2,4-Trichlorobenzene
Isopropyl ether (DIPE)	1,1,1,2-Tetrachloroethane	1,2,3-Trichloropropane
Methylene Chloride	Tetrachloroethene	1,2,4-Trimethylbenzene
Methyl-t-butyl-ether (MTBE)	Toluene	1,3,5-Trimethylbenzene
Tert-Amyl methyl ether (TAME)	1,1,2-trichloroethane	
1,1,1-Trichloroethane	Trichloroethene	
Trichlorofluoromethane	m/p-Xylenes	
1,1,2-Trichloro-1,2,2-trifluoroethane	o-Xylene	
Vinyl Acetate		
Vinyl Chloride		
SURROGATES		
1,2-Dichloroethane-d_4	Toluene-d_8	4-Bromofluorobenzene
Dibromofluoromethane		

Figure 1: **PEAK EVALUATION TECHNIQUES**

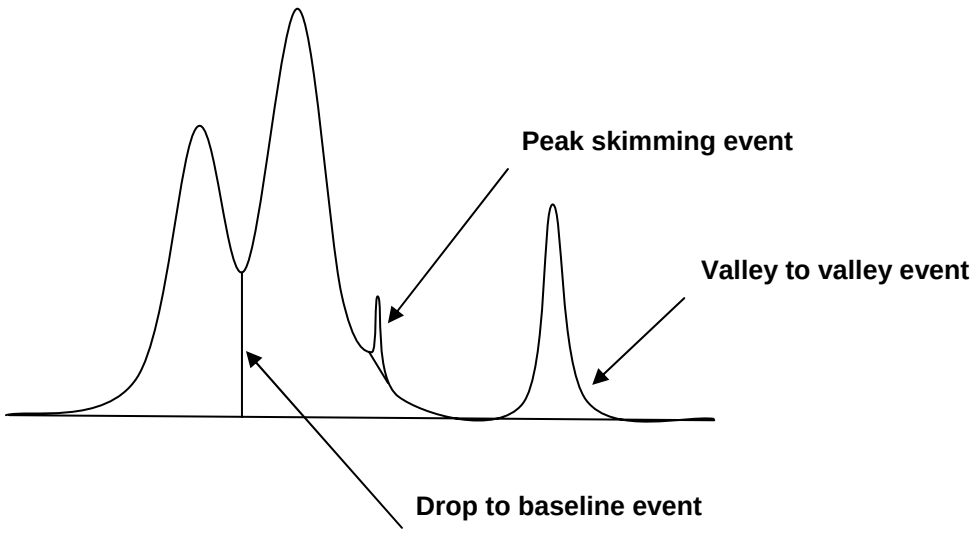

Figure 2: **TYPICAL CHROMATOGRAM FOR 5 ml**

Quantitation Report

Data File : D:\HPCHEM\1\DATA\11E12\REP061.D
Acq On : 12 May 2011 9:56 am
Sample : IVO02E111 50ppb
Misc : 50ppb 8260/250ppb TBA-KET-AA
MS Integration Params: RTE.P
Quant Time: May 12 11:26 2011

Vial: 2
Operator: CGM
Inst : TO02
Multiplr: 1.00
Quant Results File: VO02E11.RES

Method : D:\HPCHEM\1\METHODS\VO02E11.M (RTE Integrator)
Title : METHOD 8260 5.0mL
Last Update : Thu May 12 11:21:25 2011
Response via : Initial Calibration

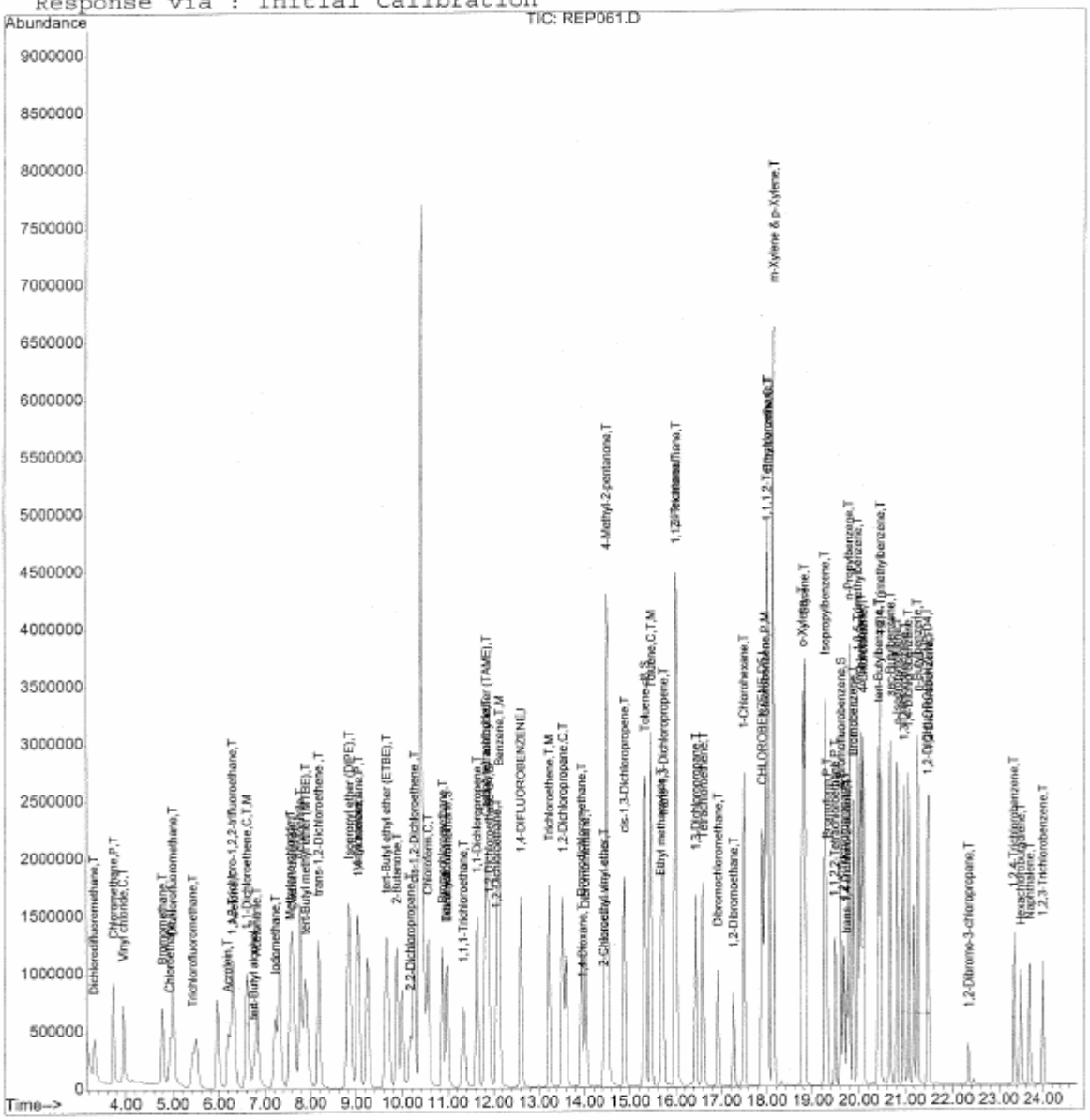

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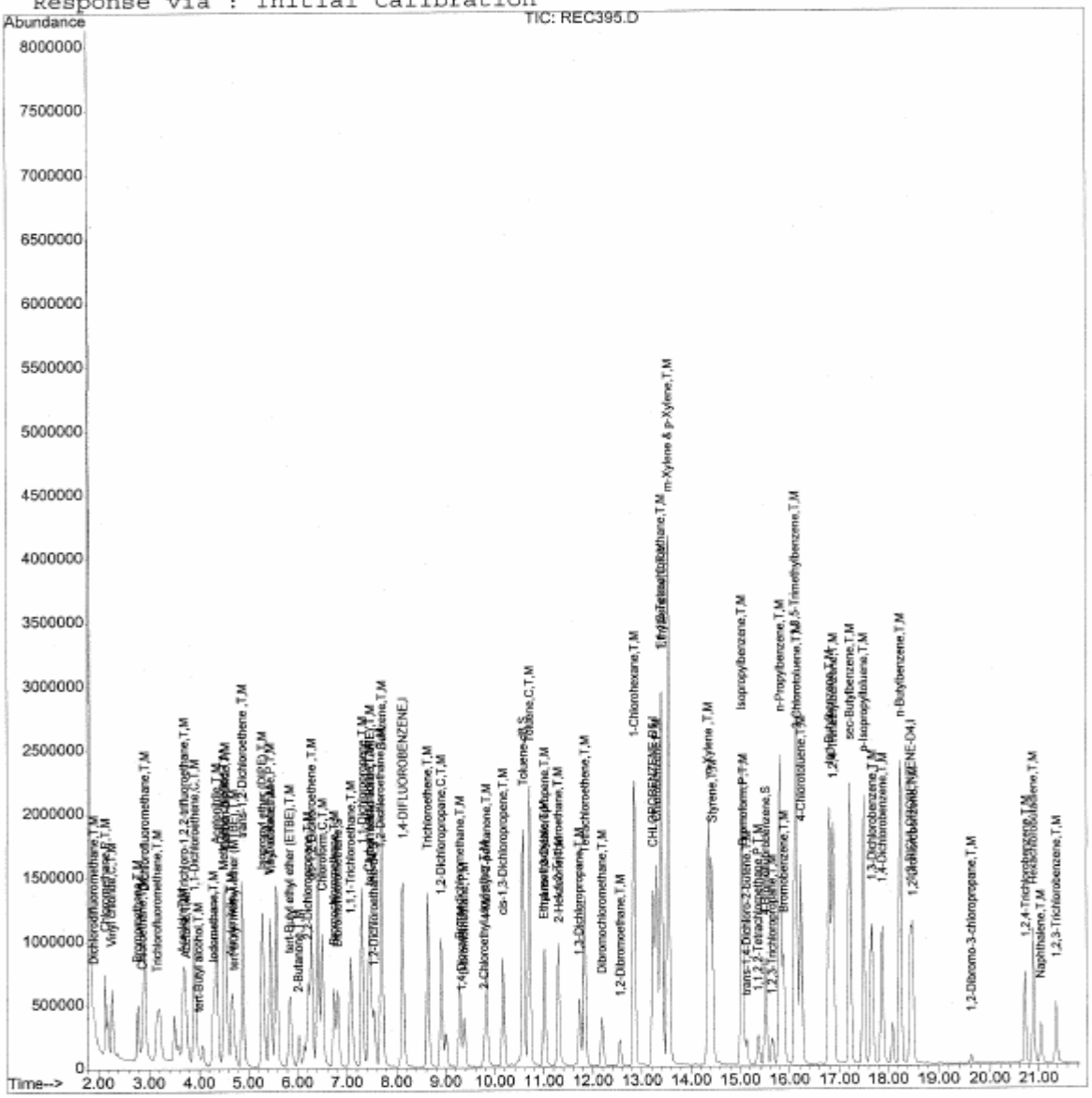
Figure 2a: **TYPICAL CHROMATOGRAM FOR 25 ml**

Quantitation Report

Data File : D:\HPCHEM\1\DATA\11E25\REC395.D Vial: 2
Acq On : 25 May 2011 1:40 pm Operator: AS
Sample : IV067E2402 10ppb Inst : TO67
Misc : 10ppb 8260/50ppb KET-ACR-ACN-TBA Multiplr: 1.00
MS Integration Params: LSCINT1.P
Quant Time: May 25 16:32 2011 Quant Results File: VO67E24.RES

Method : D:\HPCHEM\1\METHODS\VO67E24.M (RTE Integrator)
Title : METHOD 8260B 4.0
Last Update : Wed May 25 16:26:28 2011
Response via : Initial Calibration



REC395.D VO67E24.M Wed May 25 16:38:57 2011 Page 4

Figure 3: **TYPICAL ICAL SUMMARY FOR 5 ml**

INITIAL_CALIBRATION - RELATIVE_RESPONSE_FACTOR

Instrument ID :TOO2
Beginning DateTime :05/11/11 08:20
Spike Units :PPB
IC File :REP053

Column Spec :RTX502.2 ID :0.32MM
Ending DateTime :05/11/11 15:06
HPChem Method :VOO2E11

M	IDX	Parameters	1 08:20 REP048	2 08:55 REP049	4 09:31 REP050	10 11:26 REP051	20 12:03 REP052	50 12:41 REP053	100 13:17 REP054	200 13:54 REP055	300 14:31 REP056	500 15:06 REP057	Av_RRF	%_RSD	Av_Rt_M
	1	1,4-DIFLUOROBENZENE	1	1	1	1	1	1	1	1	1	1	1	0	12.6129
	2	Dichlorodifluoromethane	------	0.301	0.286	0.304	0.295	0.288	0.316	0.311	0.319	0.298	0.302	3.88	3.3170
	3	Dichlorotetrafluoroethane	------	------	------	------	------	------	------	------	------	------	0.000	0.00	0.0000
	4	Chloromethane	0.641	0.656	0.612	0.692	0.661	0.603	0.662	0.637	0.680	0.637	0.648	4.31	3.7387
	5	Vinyl chloride	0.377	0.522	0.514	0.541	0.516	0.433	0.427	0.383	0.544	0.511	0.477	13.60	3.9558
	6	Bromomethane	0.373	0.352	0.342	0.386	0.364	0.346	0.386	0.369	0.373	0.345	0.364	4.55	4.7823
	7	Chloroethane	0.220	0.304	0.281	0.310	0.303	0.286	0.323	0.313	0.317	0.289	0.294	10.11	4.9429
	8	Dichlorofluoromethane	0.816	0.792	0.784	0.732	0.789	0.751	0.707	0.737	0.754	0.729	0.759	4.54	5.0083
	9	Trichlorofluoromethane	------	0.332	0.337	0.363	0.361	0.355	0.398	0.393	0.401	0.382	0.369	6.94	5.4363
5	10	Acrolein	0.063	0.057	0.053	0.055	0.058	0.057	0.058	0.057	0.057	0.054	0.057	4.67	6.2022
	11	1,1,2-Trichloro-1,2,2-trifluoroethane	0.220	0.214	0.221	0.206	0.221	0.226	0.215	0.226	0.234	0.232	0.222	3.83	6.2854
5	12	Acetone	0.285	0.197	0.162	0.158	0.156	0.138	0.139	0.136	0.136	0.136	0.164	28.41	6.3285
	13	1,1-Dichloroethene	0.603	0.645	0.609	0.590	0.639	0.635	0.597	0.643	0.677	0.669	0.631	4.75	6.6125
5	14	tert-Butyl alcohol	0.047	0.045	0.048	0.046	0.053	0.050	0.053	0.052	0.051	0.048	0.049	5.75	6.7805
10	15	Acetonitrile	0.090	0.073	0.076	0.073	0.077	0.073	0.073	0.073	0.072	0.070	0.075	7.42	6.8340
	16	Methyl Acetate	------	------	------	------	------	------	------	------	------	------	0.000	0.00	0.0000
	17	Iodomethane	0.592	0.625	0.625	0.604	0.658	0.640	0.607	0.646	0.661	0.657	0.631	3.93	7.2265
	18	Methylene chloride	1.239	0.914	0.639	0.615	0.675	0.647	0.601	0.639	0.647	0.630	0.725	27.83	7.5685
	19	Carbon disulfide	1.244	1.323	1.486	1.399	1.427	1.363	1.515	1.439	1.529	1.413	1.414	6.20	7.6220
5	20	Acrylonitrile	0.175	0.170	0.176	0.172	0.188	0.178	0.181	0.183	0.186	0.185	0.180	3.37	7.7781
	21	tert-Butyl methyl ether (MTBE)	1.010	1.087	1.037	1.071	1.166	1.111	1.090	1.142	1.163	1.154	1.103	4.90	7.8940
	22	trans-1,2-Dichloroethene	0.619	0.660	0.626	0.615	0.678	0.654	0.622	0.656	0.664	0.650	0.644	3.40	8.1750
	23	Isopropyl ether (DIPE)	1.816	1.925	1.832	1.837	2.018	1.931	1.835	1.940	1.967	1.776	1.888	4.16	8.8396
	24	Vinyl acetate	0.636	0.877	0.785	0.857	0.848	0.866	0.977	0.892	0.854	0.780	0.837	10.69	9.0388
	25	1,1-Dichloroethane	0.779	0.808	0.776	0.763	0.840	0.809	0.766	0.814	0.826	0.821	0.800	3.39	9.0418
5	26	2-Butanol	------	------	------	------	------	------	------	------	------	------	0.000	0.00	0.0000
	27	tert-Butyl ethyl ether (ETBE)	1.291	1.308	1.287	1.314	1.448	1.403	1.346	1.432	1.453	1.434	1.372	5.01	9.6737
5	28	2-Butanone	0.299	0.276	0.244	0.245	0.269	0.252	0.255	0.254	0.257	0.236	0.259	7.06	9.8893
	29	2,2-Dichloropropane	0.323	0.322	0.304	0.267	0.299	0.291	0.266	0.265	0.253	0.230	0.282	10.91	10.1806
	30	cis-1,2-Dichloroethene	0.444	0.477	0.468	0.459	0.503	0.489	0.461	0.489	0.499	0.500	0.479	4.21	10.2610
	31	Chloroform	0.711	0.671	0.672	0.646	0.705	0.681	0.642	0.687	0.702	0.701	0.682	3.57	10.5702
	32	Bromochloromethane	0.464	0.461	0.450	0.455	0.502	0.478	0.458	0.486	0.491	0.486	0.473	3.74	10.8735
	33	Tetrahydrofuran	------	0.154	0.168	0.163	0.171	0.152	0.158	0.158	0.158	0.156	0.160	4.02	10.9835
	34	Dibromofluoromethane	------	------	0.357	0.385	0.394	0.377	0.405	0.397	0.411	0.409	0.392	4.69	10.9766
	35	1,1,1-Trichloroethane	0.382	0.407	0.397	0.366	0.401	0.398	0.375	0.395	0.394	0.384	0.390	3.32	11.3433
	36	Cyclohexane	------	------	------	------	------	------	------	------	------	------	0.000	0.00	0.0000
	37	tert-Amyl methyl ether (TAME)	0.191	0.211	0.198	0.208	0.229	0.223	0.223	0.235	0.240	0.236	0.220	7.67	11.8577
	38	1,2-Dichloroethane-d4	------	------	0.350	0.372	0.384	0.365	0.389	0.378	0.392	0.390	0.378	3.84	11.9021
	39	CHLOROBENZENE-D5	1	1	1	1	1	1	1	1	1	1	1	0	17.8953
	40	1,1-Dichloropropene	0.228	0.221	0.209	0.202	0.214	0.211	0.205	0.221	0.224	0.234	0.217	4.85	11.6391
	41	Carbon tetrachloride	0.384	0.400	0.422	0.382	0.412	0.414	0.397	0.429	0.434	0.446	0.412	5.18	11.8309
	42	1,2-Dichloroethane	0.533	0.482	0.501	0.497	0.530	0.519	0.500	0.529	0.539	0.561	0.519	4.59	12.0762
	43	Benzene	2.002	1.992	1.956	1.896	1.990	1.944	1.848	1.971	1.928	------	1.947	2.59	12.1214
	44	Trichloroethene	0.455	0.471	0.454	0.440	0.474	0.458	0.441	0.471	0.481	0.504	0.465	4.20	13.2314
	45	Methylcyclohexane	------	------	------	------	------	------	------	------	------	------	0.000	0.00	0.0000
	46	1,2-Dichloropropane	0.542	0.562	0.538	0.526	0.564	0.554	0.530	0.563	0.573	0.594	0.555	3.77	13.5303

Figure 3 (cont.): **TYPICAL ICAL SUMMARY FOR 5 ml**

	47	Bromodichloromethane	0.557	0.582	0.567	0.574	0.617	0.603	0.583	0.626	0.635	0.660	0.600	5.57	13.9436
20	48	1,4-Dioxane	0.004	0.004	0.004	0.004	0.005	0.005	0.004	0.005	0.005	0.005	0.004	7.68	13.9807
	49	Dibromomethane	0.310	0.292	0.303	0.297	0.319	0.312	0.301	0.318	0.322	0.332	0.311	4.00	14.0402
	50	2-Chloroethyl vinyl ether	------	------	0.185	0.198	0.227	0.230	0.240	0.272	------	------	0.225	13.62	14.4395
5	51	4-Methyl-2-pentanone	0.646	0.618	0.600	0.586	0.644	0.616	0.633	0.598	------	------	0.618	3.58	14.5060
	52	cis-1,3-Dichloropropene	0.753	0.759	0.748	0.741	0.825	0.813	0.773	0.829	0.846	0.860	0.795	5.58	14.8787
	53	Toluene-d8	------	------	1.416	1.453	1.451	1.415	1.521	1.477	1.503	------	1.462	2.79	15.3229
	54	Toluene	1.804	1.800	1.736	1.667	1.815	1.769	1.686	1.794	1.694	------	1.752	3.26	15.4615
	55	Ethyl methacrylate	0.548	0.565	0.555	0.581	0.646	0.646	0.644	0.668	0.673	0.677	0.620	8.35	15.6935
	56	trans-1,3-Dichloropropene	0.594	0.580	0.587	0.585	0.660	0.662	0.636	0.674	0.682	0.695	0.635	7.09	15.7351
5	57	2-Hexanone	0.407	0.382	0.376	0.364	0.399	0.393	0.408	0.398	------	------	0.391	3.99	16.0020
	58	1,1,2-Trichloroethane	0.385	0.387	0.379	0.380	0.415	0.406	0.393	0.407	0.413	0.417	0.398	3.76	16.0176
	59	1,3-Dichloropropane	0.672	0.680	0.698	0.683	0.734	0.724	0.698	0.730	0.732	0.739	0.709	3.60	16.4443
	60	Tetrachloroethene	0.347	0.365	0.351	0.326	0.345	0.352	0.330	0.349	0.354	0.362	0.348	3.51	16.6019
	61	Dibromochloromethane	0.375	0.398	0.402	0.398	0.449	0.441	0.431	0.458	0.465	0.460	0.428	7.45	16.9289
	62	1,2-Dibromoethane	0.402	0.420	0.413	0.405	0.448	0.437	0.426	0.444	0.452	0.450	0.430	4.42	17.2783
	63	1-Chlorohexane	0.663	0.650	0.643	0.602	0.673	0.696	0.649	0.682	0.688	0.676	0.662	4.16	17.5043
	64	Chlorobenzene	1.150	1.131	1.100	1.053	1.150	1.145	1.076	1.118	1.132	------	1.117	3.07	17.9543
	65	1,1,1,2-Tetrachloroethane	0.370	0.366	0.369	0.374	0.401	0.400	0.379	0.400	0.399	0.393	0.385	3.87	18.0113
	66	Ethylbenzene	1.857	1.832	1.767	1.704	1.864	1.873	1.743	1.812	------	------	1.807	3.43	18.0147
2	67	m-Xylene & p-Xylene	1.336	1.367	1.301	1.249	1.368	1.361	1.275	1.112	------	------	1.296	6.70	18.1336
	68	o-Xylene	1.332	1.361	1.320	1.284	1.399	1.391	1.316	1.360	1.268	------	1.337	3.35	18.7836
	69	Styrene	1.111	1.132	1.109	1.115	1.246	1.262	1.187	1.252	1.172	------	1.176	5.42	18.8265
	70	1,2-DICHLOROBENZENE-D4	1	1	1	1	1	1	1	1	1	1	1	0	21.4783
	71	Isopropylbenzene	4.457	4.291	4.364	4.073	4.448	4.472	4.081	4.425	3.987	------	4.289	4.46	19.2626
	72	Bromoform	0.687	0.698	0.721	0.758	0.813	0.815	0.786	0.839	0.841	0.813	0.777	7.42	19.3196
	73	1,1,2,2-Tetrachloroethane	1.482	1.447	1.485	1.470	1.574	1.546	1.456	1.514	1.489	1.435	1.490	2.94	19.4861
	74	4-Bromofluorobenzene	1.403	1.423	1.365	1.325	1.314	1.299	1.332	1.313	1.356	1.286	1.342	3.35	19.6065
	75	1,2,3-Trichloropropane	0.287	0.259	0.330	0.316	0.347	0.336	0.323	0.344	0.337	0.323	0.320	8.58	19.6779
	76	trans-1,4-Dichloro-2-butene	0.300	0.312	0.321	0.315	0.350	0.369	0.358	0.377	0.375	0.360	0.344	8.42	19.7388
	77	n-Propylbenzene	5.427	5.639	5.464	5.188	5.634	5.851	5.370	5.290	------	------	5.483	3.92	19.7932
	78	Bromobenzene	1.356	1.330	1.268	1.232	1.347	1.361	1.226	1.337	1.343	1.292	1.309	3.90	19.8861
	79	1,3,5-Trimethylbenzene	3.533	3.550	3.400	3.314	3.603	3.673	3.268	3.488	3.304	------	3.459	4.16	19.9862
	80	2-Chlorotoluene	3.410	3.325	3.190	3.086	3.612	3.610	3.022	3.176	3.497	------	3.325	6.64	20.0374
	81	4-Chlorotoluene	3.082	3.084	2.887	2.804	2.848	2.884	2.873	3.074	2.639	------	2.908	5.13	20.0936
	82	tert-Butylbenzene	0.831	0.734	0.732	0.698	0.774	0.783	0.711	0.763	0.768	0.750	0.754	5.09	20.4228
	83	1,2,4-Trimethylbenzene	3.611	3.535	3.286	3.210	3.516	3.530	3.166	3.360	3.127	------	3.371	5.40	20.4702
	84	sec-Butylbenzene	4.527	4.449	4.309	4.073	4.520	4.635	4.185	4.384	3.766	------	4.316	6.29	20.6750
	85	p-Isopropyltoluene	3.352	3.468	3.312	3.166	3.573	3.642	3.307	3.520	3.331	------	3.408	4.47	20.8237
	86	1,3-Dichlorobenzene	2.144	2.040	1.910	1.860	2.043	2.083	1.872	2.008	2.050	1.809	1.982	5.60	20.9729
	87	1,4-Dichlorobenzene	2.173	2.069	1.940	1.808	2.053	2.058	1.864	2.008	2.026	1.838	1.984	5.92	21.0903
	88	n-Butylbenzene	3.077	3.141	2.882	2.734	3.125	3.353	3.050	3.322	3.090	------	3.086	6.25	21.2829
	89	1,2-Dichlorobenzene	1.882	1.827	1.757	1.686	1.862	1.882	1.716	1.836	1.865	1.723	1.804	4.18	21.5081
	90	1,2-Dibromo-3-chloropropane	------	0.187	0.195	0.201	0.217	0.215	0.216	0.235	0.239	0.245	0.217	9.34	22.3388
	91	1,2,4-Trichlorobenzene	0.917	0.895	0.755	0.712	0.892	0.960	0.917	1.033	1.059	1.031	0.917	12.49	23.3501
	92	Hexachlorobutadiene	0.503	0.521	0.435	0.410	0.515	0.525	0.498	0.563	0.587	0.540	0.510	10.51	23.4944
	93	Naphthalene	2.256	1.963	1.761	1.724	2.090	2.149	2.168	2.406	2.474	2.341	2.133	11.97	23.6936
	94	1,2,3-Trichlorobenzene	0.762	0.773	0.656	0.646	0.799	0.853	0.829	0.920	0.955	0.942	0.813	13.40	24.0013

Spike Amount = Nominal Amount * M
Ave_%RSD : 6.2 Max_%RSD : 28.4

Use Least Square Linear Regression with weighting factor of inverse concentration for comps with %_RSD > 15
Resp_Ratio = xo + x1 * Amt_Ratio

IDX	Parameter	x0	x1	CCF
12	Acetone	0.01465	0.13589	0.9999
18	Methylene chloride	0.00958	0.63164	0.9997

Figure 3a: **TYPICAL ICAL SUMMARY FOR 25 ml**

INITIAL_CALIBRATION - RELATIVE_RESPONSE_FACTOR

Instrument ID :T067
Beginning DateTime :05/24/11 10:53
Spike Units :PPB
IC File :REC384

Column Spec :RTX502.2 ID :0.25MM
Ending DateTime :05/24/11 15:32
HPChem Method :V067E24

M	IDX	Parameters	.3 10:53 REC379	.5 11:24 REC380	1 11:55 REC381	2 12:26 REC382	5 12:57 REC383	10 13:28 REC384	20 13:59 REC385	30 14:30 REC386	50 15:01 REC387	100 15:32 REC388	Av_RRF	%_RSD	Av_Rt_M
	1	1,4-DIFLUOROBENZENE	1	1	1	1	1	1	1	1	1	1	1	0	8.1215
	2	Dichlorodifluoromethane	0.190	0.203	0.221	0.231	0.239	0.237	0.228	0.251	0.250	0.229	0.228	8.46	1.9137
	3	Dichlorotetrafluoroethane	------	------	------	------	------	------	------	------	------	------	0.000	0.00	0.0000
	4	Chloromethane	0.416	0.428	0.451	0.465	0.486	0.493	0.472	0.516	0.515	0.460	0.470	7.10	2.1480
	5	Vinyl chloride	0.368	0.427	0.449	0.470	0.482	0.493	0.462	0.496	0.446	0.334	0.443	12.11	2.2812
	6	Bromomethane	------	0.204	0.230	0.244	0.253	0.261	0.251	0.281	0.280	0.254	0.251	9.53	2.7775
	7	Chloroethane	------	0.237	0.257	0.279	0.276	0.286	0.275	0.302	0.305	0.280	0.277	7.60	2.8784
	8	Dichlorofluoromethane	------	0.839	0.754	0.812	0.755	0.811	0.763	0.819	0.808	0.737	0.789	4.61	2.9174
	9	Trichlorofluoromethane	0.335	0.387	0.414	0.433	0.449	0.467	0.441	0.484	0.485	0.433	0.433	10.56	3.1728
	10	sec-Propyl alcohol	------	------	------	------	------	------	------	------	------	------	0.000	0.00	0.0000
5	11	Acrolein	------	------	0.018	0.014	0.013	0.015	0.013	0.014	0.014	0.013	0.014	11.61	3.6572
	12	1,1,2-Trichloro-1,2,2-trifluoroethane	0.248	0.244	0.221	0.248	0.228	0.246	0.232	0.252	0.250	0.230	0.240	4.59	3.6984
5	13	Acetone	------	------	------	0.041	0.033	0.032	0.030	0.031	0.030	0.027	0.032	13.76	3.7288
5	14	tert-Butyl alcohol	------	0.018	0.015	0.016	0.014	0.016	0.015	0.016	0.016	0.013	0.015	9.20	3.9927
	15	1,1-Dichloroethene	0.712	0.724	0.681	0.757	0.703	0.754	0.713	0.771	0.767	0.693	0.728	4.46	3.8961
10	16	Acetonitrile	0.083	0.085	0.079	0.088	0.080	0.089	0.083	0.088	0.089	0.079	0.084	4.82	4.3470
	17	Methyl acetate	------	------	------	------	------	------	------	------	------	------	0.000	0.00	0.0000
	18	Iodomethane	0.537	0.546	0.532	0.582	0.545	0.589	0.564	0.605	0.601	0.555	0.566	4.77	4.2885
	19	Methylene chloride	------	0.766	0.634	0.638	0.485	0.506	0.473	0.500	0.495	0.441	0.549	19.41	4.5003
	20	Carbon disulfide	1.365	1.725	1.524	1.365	1.239	1.268	1.234	1.280	1.285	1.170	1.346	12.27	4.5213
5	21	Acrylonitrile	0.050	0.047	0.046	0.042	0.044	0.046	0.044	0.046	0.047	0.043	0.045	5.07	4.6633
	22	tert-Butyl methyl ether (MTBE)	0.365	0.354	0.337	0.396	0.341	0.379	0.359	0.383	0.393	0.372	0.368	5.53	4.6969
	23	trans-1,2-Dichloroethene	0.680	0.700	0.652	0.725	0.674	0.734	0.689	0.746	0.743	0.670	0.701	4.79	4.8800
	24	Isopropyl ether (DIPE)	1.285	1.300	1.150	1.322	1.221	1.323	1.257	1.352	1.345	1.195	1.275	5.31	5.2957
	25	Vinyl acetate	0.287	0.317	0.315	0.334	0.333	0.378	0.364	0.378	0.412	------	0.346	11.34	5.4521
	26	1,1-Dichloroethane	0.746	0.732	0.699	0.780	0.710	0.781	0.739	0.796	0.794	0.720	0.750	4.76	5.4422
5	27	2-Butanol	------	------	------	------	------	------	------	------	------	------	0.000	0.00	0.0000
	28	tert-Butyl ethyl ether (ETBE)	0.530	0.522	0.500	0.615	0.522	0.601	0.570	0.618	0.638	0.630	0.575	9.05	5.8521
5	29	2-Butanone	0.051	0.051	0.055	0.050	0.051	0.054	0.052	0.056	0.056	0.051	0.053	4.25	6.0249
	30	2,2-Dichloropropane	------	0.466	0.422	0.453	0.397	0.425	0.395	0.397	0.384	0.322	0.407	10.42	6.2181
	31	cis-1,2-Dichloroethene	0.385	0.403	0.373	0.412	0.378	0.417	0.392	0.424	0.424	0.383	0.399	4.87	6.2840
	32	Chloroform	0.570	0.605	0.578	0.620	0.572	0.627	0.593	0.639	0.634	0.571	0.601	4.58	6.5066
	33	Bromochloromethane	0.271	0.281	0.252	0.283	0.264	0.285	0.272	0.289	0.291	0.261	0.275	4.73	6.7379
5	34	tert-Amyl alcohol	------	------	------	------	------	------	------	------	------	------	0.000	0.00	0.0000
	35	Dibromofluoromethane	0.293	0.277	0.303	0.311	0.292	0.327	0.305	0.319	0.329	0.301	0.306	5.29	6.8155
	36	1,1,1-Trichloroethane	------	0.545	0.522	0.581	0.536	0.588	0.555	0.592	0.590	0.530	0.560	5.03	7.0771
	37	Cyclohexane	------	------	------	------	------	------	------	------	------	------	0.000	0.00	0.0000
	38	tert-Amyl methyl ether (TAME)	0.068	0.074	0.072	0.079	0.069	0.080	0.076	0.084	0.085	0.084	0.077	8.19	7.4773
	39	1,2-Dichloroethane-d4	------	0.227	0.243	0.238	0.220	0.239	0.226	0.233	0.238	0.217	0.231	3.95	7.5375
	40	CHLOROBENZENE-D5	1	1	1	1	1	1	1	1	1	1	1	0	13.2312
	41	1,1-Dichloropropene	0.259	0.264	0.237	0.267	0.248	0.274	0.257	0.276	0.283	0.262	0.263	5.13	7.3016
	42	Carbon tetrachloride	0.633	0.643	0.591	0.664	0.608	0.665	0.628	0.673	0.691	0.633	0.643	4.73	7.4480
	43	1,2-Dichloroethane	0.380	0.388	0.355	0.395	0.360	0.390	0.368	0.384	0.395	0.353	0.377	4.33	7.6822
	44	Benzene	1.952	1.966	1.758	1.957	1.780	1.959	1.843	1.973	2.016	1.641	1.885	6.49	7.6969
	45	Trichloroethene	0.490	0.506	0.458	0.506	0.471	0.516	0.491	0.527	0.546	0.503	0.502	5.15	8.6324
	46	Methylcyclohexane	------	------	------	------	------	------	------	------	------	------	0.000	0.00	0.0000
	47	1,2-Dichloropropane	0.448	0.457	0.417	0.469	0.422	0.458	0.434	0.461	0.475	0.432	0.447	4.46	8.9106
20	48	1,4-Dioxane	------	------	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	4.59	9.3067

Figure 3a (cont.): **TYPICAL ICAL SUMMARY FOR 25 ml**

	49	Bromodichloromethane	0.475	0.474	0.457	0.509	0.461	0.504	0.489	0.509	0.527	0.479	0.488	4.72	9.2781
	50	Dibromomethane	0.150	0.155	0.157	0.157	0.159	0.174	0.166	0.172	0.178	0.161	0.163	5.63	9.3659
	51	2-Chloroethyl vinyl ether	------	------	------	0.058	0.051	0.060	0.060	0.065	0.074	------	0.061	12.54	9.7757
5	52	4-Methyl-2-pentanone	0.148	0.152	0.155	0.154	0.159	0.170	0.168	0.178	0.185	0.167	0.164	7.36	9.8227
	53	cis-1,3-Dichloropropene	0.541	0.557	0.516	0.578	0.527	0.579	0.555	0.586	0.605	0.548	0.559	4.98	10.1697
	54	Toluene-d8	1.578	1.429	1.512	1.548	1.474	1.637	1.528	1.589	1.666	1.458	1.542	5.00	10.5694
	55	Toluene	1.885	1.903	1.758	1.930	1.783	1.969	1.842	1.986	2.025	1.605	1.869	6.75	10.7056
	56	Ethyl methacrylate	0.238	0.215	0.218	0.239	0.223	0.244	0.235	0.248	0.261	0.236	0.236	6.00	11.0043
	57	trans-1,3-Dichloropropene	0.367	0.386	0.356	0.388	0.364	0.396	0.381	0.400	0.416	0.376	0.383	4.72	11.0189
5	58	2-Hexanone	0.094	0.082	0.094	0.091	0.095	0.102	0.100	0.107	0.109	0.098	0.097	8.28	11.3044
	59	1,1,2-Trichloroethane	0.179	0.183	0.171	0.192	0.173	0.189	0.181	0.190	0.196	0.177	0.183	4.56	11.2839
	60	1,3-Dichloropropane	0.360	0.369	0.333	0.371	0.348	0.378	0.358	0.375	0.386	0.349	0.363	4.48	11.7231
	61	Tetrachloroethene	0.395	0.364	0.344	0.381	0.348	0.387	0.361	0.389	0.399	0.366	0.373	5.23	11.8271
	62	Dibromochloromethane	0.233	0.242	0.223	0.245	0.225	0.251	0.241	0.251	0.262	0.237	0.241	5.04	12.1902
	63	1,2-Dibromoethane	0.175	0.186	0.174	0.196	0.185	0.201	0.194	0.202	0.211	0.190	0.191	6.12	12.5445
	64	1-Chlorohexane	0.815	0.826	0.746	0.850	0.803	0.886	0.846	0.906	0.931	0.845	0.845	6.33	12.8388
	65	Chlorobenzene	1.051	1.067	0.963	1.083	0.995	1.090	1.034	1.113	1.131	1.025	1.055	4.95	13.3029
	66	Ethylbenzene	2.090	2.087	1.953	2.189	2.031	2.236	2.114	2.284	2.324	------	2.145	5.68	13.3973
	67	1,1,1,2-Tetrachloroethane	0.304	0.317	0.287	0.322	0.301	0.330	0.313	0.335	0.342	0.311	0.316	5.31	13.3805
2	68	m-Xylene & p-Xylene	1.531	1.534	1.428	1.612	1.487	1.660	1.564	1.675	1.585	------	1.564	5.09	13.5388
	69	o-Xylene	1.457	1.454	1.368	1.523	1.422	1.563	1.480	1.591	1.598	1.400	1.486	5.41	14.3512
	70	Styrene	1.016	1.038	0.988	1.117	1.056	1.177	1.124	1.209	1.236	1.117	1.108	7.50	14.4185
	71	1,2-DICHLOROBENZENE-D4	1	1	1	1	1	1	1	1	1	1	1	0	18.4521
	72	Isopropylbenzene	7.331	7.076	6.756	7.443	6.910	7.931	7.372	8.023	8.322	6.336	7.350	8.36	15.0305
	73	Bromoform	0.293	0.369	0.350	0.374	0.354	0.401	0.385	0.410	0.437	0.388	0.376	10.44	15.0510
	74	1,1,2,2-Tetrachloroethane	0.646	0.696	0.598	0.675	0.605	0.672	0.642	0.672	0.704	0.614	0.652	5.76	15.3673
	75	4-Bromofluorobenzene	1.978	1.597	1.606	1.586	1.458	1.659	1.523	1.611	1.708	1.524	1.625	8.80	15.5107
	76	1,2,3-Trichloropropane	0.150	0.171	0.159	0.183	0.165	0.182	0.173	0.183	0.194	0.169	0.173	7.57	15.6469
	77	trans-1,4-Dichloro-2-butene	------	0.209	0.213	0.246	0.221	0.247	0.237	0.255	------	------	0.233	7.81	15.1329
	78	n-Propylbenzene	8.931	8.868	8.388	9.164	8.679	9.903	9.219	10.162	10.454	------	9.308	7.60	15.7968
	79	Bromobenzene	1.103	1.125	1.069	1.153	1.053	1.202	1.128	1.218	1.274	1.118	1.144	6.00	15.8783
	80	1,3,5-Trimethylbenzene	5.870	5.511	5.291	5.913	5.595	6.225	5.869	6.346	6.421	5.442	5.848	6.69	16.1110
	81	2-Chlorotoluene	5.659	5.348	5.194	5.735	5.222	5.921	5.535	6.078	6.035	5.220	5.595	6.14	16.1315
	82	4-Chlorotoluene	4.316	4.515	3.910	4.213	3.990	4.496	4.202	4.560	4.867	4.291	4.336	6.56	16.2311
	83	tert-Butylbenzene	1.211	1.171	1.142	1.263	1.185	1.374	1.276	1.376	1.404	1.288	1.269	7.31	16.8021
	84	1,2,4-Trimethylbenzene	5.156	5.058	4.833	5.379	5.113	5.737	5.349	5.810	5.885	5.113	5.343	6.69	16.8753
	85	sec-Butylbenzene	7.773	7.533	7.185	7.982	7.605	8.755	8.093	8.688	8.924	6.624	7.916	9.24	17.2150
	86	p-Isopropyltoluene	5.830	5.694	5.440	6.059	5.930	6.709	6.280	6.783	6.872	5.705	6.130	8.28	17.4902
	87	1,3-Dichlorobenzene	2.387	2.227	2.042	2.229	2.095	2.353	2.205	2.389	2.439	2.161	2.253	5.97	17.6645
	88	1,4-Dichlorobenzene	2.188	2.115	1.953	2.087	1.938	2.155	2.042	2.229	2.245	2.004	2.096	5.26	17.8694
	89	n-Butylbenzene	5.664	5.454	5.072	5.802	5.625	6.455	6.000	6.624	6.597	5.134	5.843	9.73	18.2398
	90	1,2-Dichlorobenzene	1.765	1.626	1.535	1.698	1.578	1.729	1.619	1.745	1.769	1.587	1.665	5.17	18.4902
	91	1,2-Dibromo-3-chloropropane	------	------	0.056	0.079	0.072	0.078	0.076	0.080	0.086	0.079	0.076	11.86	19.6268
	92	1,2,4-Trichlorobenzene	1.001	0.902	0.870	0.930	0.901	1.001	0.911	0.983	0.997	0.958	0.945	5.16	20.7185
	93	Hexachlorobutadiene	0.911	0.806	0.835	0.933	0.917	1.028	0.907	0.970	0.995	0.959	0.926	7.35	20.8913
	94	Naphthalene	1.277	1.168	1.120	1.206	1.137	1.271	1.219	1.309	1.368	1.288	1.236	6.46	21.0524
	95	1,2,3-Trichlorobenzene	0.714	0.668	0.618	0.686	0.664	0.726	0.669	0.714	0.737	0.693	0.689	5.20	21.3715

Spike Amount = Nominal Amount * M
Ave_%RSD : 6.9 Max_%RSD : 19.4

Use Least Square Linear Regression with weighting factor of inverse concentration for comps with %_RSD > 15
Resp_Ratio = xo + x1 * Amt_Ratio

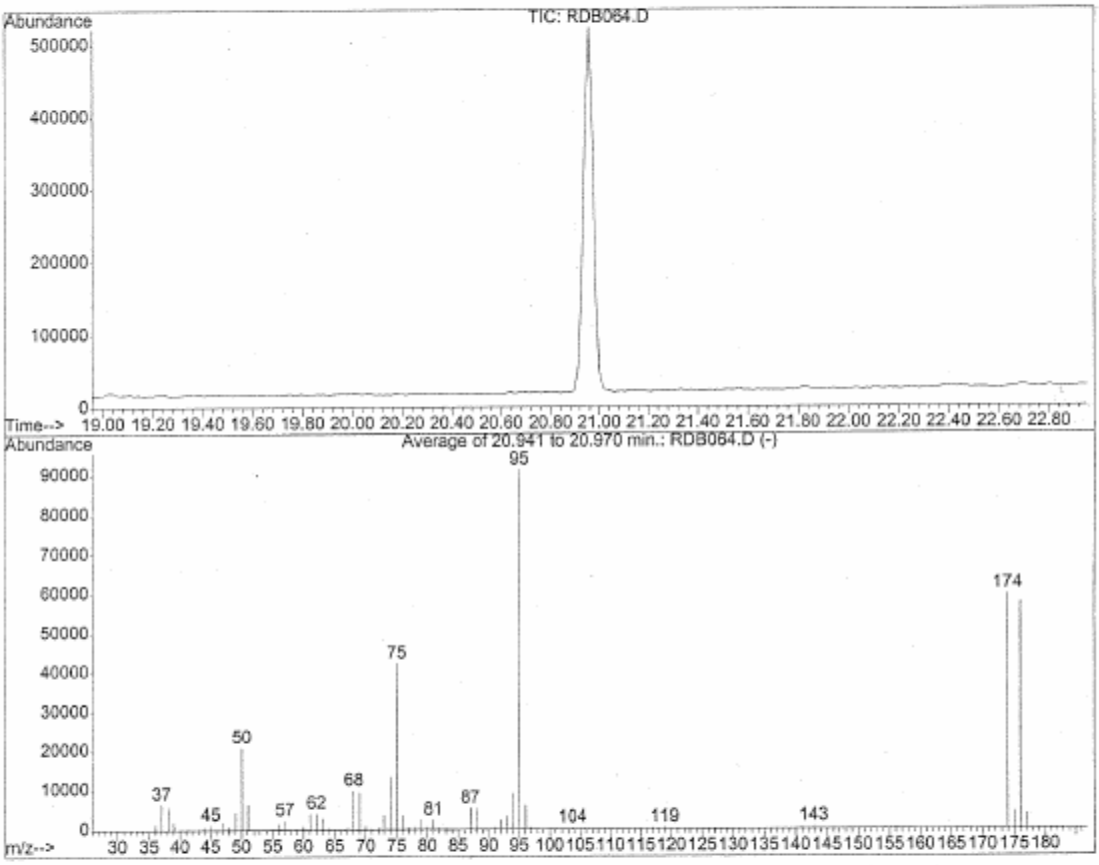
IDX	Parameter	x0	x1	CCF
19	Methylene chloride	0.01951	0.46384	0.9983

Figure 4: **TYPICAL INSTRUMENT PERFORMANCE CHECK (TUNING)**

BFB

Data File : D:\HPCHEM\1\DATA\11D07\RDB064.D
Acq On : 7 Apr 2011 7:43 pm
Sample : BFB03D04
Misc : T/CHECK
MS Integration Params: 524INT.P
Method : D:\HPCHEM\1\METHODS\VO03D07.M (RTE Integrator)
Title : METHOD 8260 25mL

Vial: 2
Operator: MW
Inst : TO03
Multiplr: 1.00



AutoFind: Scans 1163, 1164, 1165; Background Corrected with Scan 1156

Target Mass	Rel. to Mass	Lower Limit%	Upper Limit%	Rel. Abn%	Raw Abn	Result Pass/Fail
50	95	15	40	22.9	20916	PASS
75	95	30	60	46.4	42347	PASS
95	95	100	100	100.0	91301	PASS
96	95	5	9	6.6	6055	PASS
173	174	0.00	2	0.0	0	PASS
174	95	50	100	65.3	59619	PASS
175	174	5	9	7.4	4406	PASS
176	174	95	101	96.7	57635	PASS
177	176	5	9	6.7	3884	PASS

RDB064.D VO03D07.M Fri Apr 08 09:01:53 2011

Figure 4a: TYPICAL INSTRUMENT PERFORMANCE CHECK (TUNING) SUMMARY

5A
VOLATILE ORGANIC INSTRUMENT PERFORMANCE CHECK
BROMOFLUOROBENZENE (BFB)

Lab Name: EMAX Inc
Lab Code: EMXT Case No.:
Lab File ID: RDW647
Instrument ID: TO06
GC Column:RTX502.2ID:0.32mm (mm)

Contract: CLEAN WATER PROJECT
SAS No.: SDG No.: 11D289
BFB Injection Date : 04/29/11
BFB Injection Time : 08:50
Heated Purge: (Y/N) N

m/e	ION ABUNDANCE CRITERIA	% RELATIVE ABUNDANCE
50	15.0 - 40.0% of mass 95	28.62
75	30.0 - 60.0% of mass 95	43.44
95	Base peak, 100% relative abundance	100.00
96	5.0 - 9.0% of mass 95	6.43
173	Less than 2.0% of mass 174	0.00(0.0)1
174	Greater than 50% of mass 95	80.75
175	5.0 - 9.0% of mass 174	5.72(7.1)1
176	95.0 - 101.0% of mass 174	76.92(95.3)1
177	5.0 - 9.0% of mass 176	5.63(7.3)2

1-Value is % mass 174 2-Value is % mass 176

THIS CHECK APPLIES TO THE FOLLOWING SAMPLES, MS, MSD,BLANKS, AND STANDARDS:

	EPA SAMPLE NO.	LAB SAMPLE ID	LAB FILE ID	DATE ANALYZED	TIME ANALYZED
1	VSTD010	CV006C2337	RDW648	04/29/11	09:24
2	MBLK1W	V006D35B	RDW651	04/29/11	11:17
3	LCS1W	V006D35L	RDW649	04/29/11	10:12
4	LCD1W	V006D35C	RDW650	04/29/11	10:45
5	MW013B-41	D289-01	RDW657	04/29/11	14:37
6	MW013B-41MS	D289-01M	RDW658	04/29/11	15:09
7	MW013B-41MSD	D289-01S	RDW659	04/29/11	15:42
8	MW005B-41	D289-02	RDW661	04/29/11	16:50
9	MW005B-41RIN	D289-03	RDW662	04/29/11	17:23

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FORM V VOA OLM02.0

Figure 5: TYPICAL INTERNAL STANDARD AREA AND RETENTION TIME SUMMARY

8A
VOLATILE INTERNAL STANDARD AREA AND RT SUMMARY

Lab Name: EMAX Inc
Lab Code: EMXT
Lab File ID: RCW334
Instrument ID: TO06
GC Column: RTX502.2 ID: 0.32mm (mm)

Project: CLEAN WATER PROJECT
SDG No.: 11D289
Date Analyzed: 03/23/11
Time Analyzed: 21:09
Heated Purge: (Y/N) N

		IS1(DBF)		IS2(CBZ)		IS3(DCB)	
		AREA #	RT #	AREA #	RT #	AREA #	RT #
	12 HOUR STD	1072199	8.23	1018835	13.36	453244	18.55
	UPPER LIMIT	2144398	8.73	2037670	13.86	906488	19.05
	LOWER LIMIT	536100	7.73	509418	12.86	226622	18.05
	SAMPLE ID						
1	VSTD010	1371563	8.24	1259317	13.35	528942	18.54
2	MBLK1W	1578413	8.24	1471852	13.35	645186	18.55
3	LCS1W	1500572	8.24	1364194	13.35	568220	18.54
4	LCD1W	1379888	8.23	1286422	13.35	544587	18.54
5	MW013B-41	1485480	8.24	1374830	13.35	587781	18.54
6	MW013B-41MS	1380777	8.24	1279650	13.36	543307	18.55
7	MW013B-41MSD	1329724	8.24	1224316	13.35	503571	18.55
8	MW005B-41	1445970	8.24	1360810	13.37	573360	18.55
9	MW005B-41RIN	1419061	8.24	1326088	13.37	553494	18.55

IS1 (DFB) = 1,4-Difluorobenzene
IS2 (CBZ) = Chlorobenzene-d5
IS3 (DCB) = 1,2-Dichlorobenzene-d4

AREA UPPER LIMIT = + 100% of internal standard area
AREA LOWER LIMIT = - 50% of internal standard area
RT UPPER LIMIT = + 0.50 minutes of internal standard RT
RT LOWER LIMIT = - 0.50 minutes of internal standard RT

Column used to flag internal standard area values with an asterisk
* Values outside of QC limits.

page 1 of 1

FORM VIII VOA-8260 1/2000

Figure 6: **TYPICAL SAMPLE RESULT SUMMARY FORM**

METHOD 5030B/8260B
VOLATILE ORGANICS BY GC/MS

Client : XYZ, INC.	Date Collected: 04/27/11
Project : CLEAN WATER PROJECT	Date Received: 04/29/11
Batch No. : 11D289	Date Extracted: 04/29/11 14:37
Sample ID: MW013B-41	Date Analyzed: 04/29/11 14:37
Lab Samp ID: D289-01	Dilution Factor: 1
Lab File ID: RDW657	Matrix : WATER
Ext Btch ID: VO06D35	% Moisture : NA
Calib. Ref.: RCW334	Instrument ID : T-006

PARAMETERS	RESULTS (ug/L)	RL (ug/L)	LOD (ug/L)
1,1,1-TRICHLOROETHANE	ND	1.0	0.20
1,1,2,2-TETRACHLOROETHANE	ND	1.0	0.20
1,1,2-TRICHLOROETHANE	ND	1.0	0.20
1,1-DICHLOROETHANE	ND	1.0	0.20
1,1-DICHLOROETHENE	ND	1.0	0.20
1,2-DICHLOROETHANE	ND	1.0	0.20
1,2-DICHLOROPROPANE	ND	1.0	0.20
2-BUTANONE	ND	20	4.0
2-HEXANONE	ND	20	4.0
4-METHYL-2-PENTANONE	ND	10	4.0
ACETONE	ND	20	5.0
BENZENE	ND	1.0	0.20
BROMODICHLOROMETHANE	ND	1.0	0.20
BROMOFORM	ND	1.0	0.30
BROMOMETHANE	ND	1.0	0.30
CARBON TETRACHLORIDE	ND	1.0	0.20
CHLOROBENZENE	ND	1.0	0.20
CHLOROETHANE	ND	1.0	0.30
CHLOROFORM	ND	1.0	0.20
CHLOROMETHANE	ND	1.0	0.30
CIS-1,2-DICHLOROETHENE	ND	1.0	0.20
CIS-1,3-DICHLOROPROPENE	ND	1.0	0.20
DIBROMOCHLOROMETHANE	ND	1.0	0.20
ETHYLBENZENE	ND	1.0	0.20
METHYLENE CHLORIDE	ND	1.0	0.50
M/P-XYLENES	ND	2.0	0.40
O-XYLENE	ND	1.0	0.20
STYRENE	ND	1.0	0.20
TETRACHLOROETHENE	ND	1.0	0.20
TOLUENE	ND	1.0	0.20
TRANS-1,2-DICHLOROETHENE	ND	1.0	0.20
TRANS-1,3-DICHLOROPROPENE	ND	1.0	0.20
TRICHLOROETHENE	ND	1.0	0.20
VINYL CHLORIDE	ND	1.0	0.20

SURROGATE PARAMETERS	RESULTS	SPK_AMT	% RECOVERY	QC LIMIT
1,2-DICHLOROETHANE-D4	9.30	10.00	93.0	70-120
4-BROMOFLUOROBENZENE	9.83	10.00	98.3	75-120
TOLUENE-D8	9.97	10.00	99.7	85-120

Figure 7: TYPICAL LCS SUMMARY FORM

EMAX QUALITY CONTROL DATA
LCS/LCD ANALYSIS

CLIENT: XYZ, INC.
PROJECT: CLEAN WATER PROJECT
BATCH NO.: 11D289
METHOD: METHOD 5030B/8260B

MATRIX:	WATER			% MOISTURE:	NA
DILUTION FACTOR:	1	1	1		
SAMPLE ID:	MBLK1W				
LAB SAMP ID:	VO06D35B	VO06D35L	VO06D35C		
LAB FILE ID:	RDW651	RDW649	RDW650		
DATE EXTRACTED:	04/29/1111:17	04/29/1110:12	04/29/1110:45	DATE COLLECTED:	NA
DATE ANALYZED:	04/29/1111:17	04/29/1110:12	04/29/1110:45	DATE RECEIVED:	04/29/11
PREP. BATCH:	VO06D35	VO06D35	VO06D35		
CALIB. REF:	RCW334	RCW334	RCW334		

ACCESSION:

PARAMETER	BLNK RSLT (ug/L)	SPIKE AMT (ug/L)	BS RSLT (ug/L)	BS % REC	SPIKE AMT (ug/L)	BSD RSLT (ug/L)	BSD % REC	RPD (%)	QC LIMIT (%)	MAX RPD (%)
1,1,1-Trichloroethane	ND	10.0	8.75	88	10.0	9.76	98	11	65-130	30
1,1,2,2-Tetrachloroethane	ND	10.0	10.1	101	10.0	12.0	120	17	65-130	30
1,1,2-Trichloroethane	ND	10.0	9.78	98	10.0	11.5	115	16	75-125	30
1,1-Dichloroethane	ND	10.0	9.71	97	10.0	10.6	106	9	70-135	30
1,1-Dichloroethene	ND	10.0	10.2	102	10.0	10.7	107	5	70-130	30
1,2-Dichloroethane	ND	10.0	9.82	98	10.0	11.1	111	12	70-130	30
1,2-Dichloropropane	ND	10.0	10.5	105	10.0	11.7	117	11	75-125	30
2-Butanone	ND	50.0	43.8	88	50.0	53.1	106	19	50-150	30
2-Hexanone	ND	50.0	47.1	94	50.0	57.0	114	19	55-130	30
4-Methyl-2-Pentanone	ND	50.0	44.9	90	50.0	54.3	109	19	60-135	30
Acetone	ND	50.0	39.2	78	50.0	45.2	90	14	40-140	30
Benzene	ND	10.0	9.98	100	10.0	10.7	107	7	80-120	30
Bromodichloromethane	ND	10.0	9.10	91	10.0	10.3	103	13	75-120	30
Bromoform	ND	10.0	8.94	89	10.0	10.0	100	11	70-130	30
Bromomethane	ND	10.0	8.03	80	10.0	8.61	86	7	30-145	30
Carbon Tetrachloride	ND	10.0	9.94	99	10.0	10.5	105	6	65-140	30
Chlorobenzene	ND	10.0	9.96	100	10.0	11.0	110	10	80-120	30
Chloroethane	ND	10.0	8.62	86	10.0	9.05	90	5	60-135	30
Chloroform	ND	10.0	9.21	92	10.0	10.3	103	11	65-135	30
Chloromethane	ND	10.0	10.2	102	10.0	10.5	105	4	40-125	30
cis-1,2-Dichloroethene	ND	10.0	8.64	86	10.0	9.54	95	10	70-125	30
cis-1,3-Dichloropropene	ND	10.0	9.87	99	10.0	11.0	110	10	70-130	30
Dibromochloromethane	ND	10.0	9.33	93	10.0	10.6	106	13	60-135	30
Ethylbenzene	ND	10.0	9.78	98	10.0	10.7	107	9	75-125	30
Methylene Chloride	ND	10.0	9.21	92	10.0	10.4	104	12	55-140	30
m/p-Xylenes	ND	20.0	19.4	97	20.0	21.0	105	8	75-130	30
o-Xylene	ND	10.0	9.70	97	10.0	10.5	105	8	75-130	30
Styrene	ND	10.0	9.08	91	10.0	10.0	100	10	65-135	30
Tetrachloroethene	ND	10.0	9.85	98	10.0	10.4	104	6	45-150	30
Toluene	ND	10.0	9.79	98	10.0	10.5	105	7	75-120	30
Trans-1,2-Dichloroethene	ND	10.0	9.40	94	10.0	10.1	101	7	60-140	30
Trans-1,3-Dichloropropene	ND	10.0	9.67	97	10.0	10.9	109	12	55-140	30
Trichloroethene	ND	10.0	10.4	104	10.0	11.2	112	7	70-125	30
Vinyl Chloride	ND	10.0	10.1	101	10.0	10.4	104	2	50-145	30

SURROGATE PARAMETER	SPIKE AMT (ug/L)	BS RSLT (ug/L)	BS % REC	SPIKE AMT (ug/L)	BSD RSLT (ug/L)	BSD % REC	QC LIMIT (%)
1,2-Dichloroethane-d4	10.0	8.82	88	10.0	9.24	92	70-120
4-Bromofluorobenzene	10.0	10.1	101	10.0	9.97	100	75-120
Toluene-d8	10.0	10.1	101	10.0	9.98	100	85-120

Figure 8: TYPICAL MS/MSD REPORT SUMMARY FORM

EMAX QUALITY CONTROL DATA
MS/MSD ANALYSIS

CLIENT: XYZ, INC.
PROJECT: CLEAN WATER PROJECT
BATCH NO.: 11D289
METHOD: METHOD 5030B/8260B

MATRIX:	WATER			% MOISTURE:	NA
DILUTION FACTOR:	1	1	1		
SAMPLE ID:	MW013B-41				
LAB SAMP ID:	D289-01	D289-01M	D289-01S		
LAB FILE ID:	RDW657	RDW658	RDW659		
DATE EXTRACTED:	04/29/1114:37	04/29/1115:09	04/29/1115:42	DATE COLLECTED:	04/27/11
DATE ANALYZED:	04/29/1114:37	04/29/1115:09	04/29/1115:42	DATE RECEIVED:	04/29/11
PREP. BATCH:	VOO6D35	VOO6D35	VOO6D35		
CALIB. REF:	RCW334	RCW334	RCW334		

ACCESSION:

PARAMETER	SMPL RSLT (ug/L)	SPIKE AMT (ug/L)	MS RSLT (ug/L)	MS % REC	SPIKE AMT (ug/L)	MSD RSLT (ug/L)	MSD % REC	RPD (%)	QC LIMIT (%)	MAX RPD (%)
1,1,1-Trichloroethane	ND	10.0	8.85	88	10.0	9.50	95	7	65-130	30
1,1,2,2-Tetrachloroethane	ND	10.0	10.5	105	10.0	11.5	115	9	65-130	30
1,1,2-Trichloroethane	ND	10.0	10.1	101	10.0	10.9	109	7	75-125	30
1,1-Dichloroethane	ND	10.0	9.94	99	10.0	10.4	104	5	70-135	30
1,1-Dichloroethene	ND	10.0	10.2	102	10.0	10.5	105	3	70-130	30
1,2-Dichloroethane	ND	10.0	10.1	101	10.0	10.9	109	8	70-130	30
1,2-Dichloropropane	ND	10.0	10.8	108	10.0	11.4	114	5	75-125	30
2-Butanone	ND	50.0	46.0	92	50.0	47.6	95	3	50-150	30
2-Hexanone	ND	50.0	49.4	99	50.0	52.8	106	7	55-130	30
4-Methyl-2-Pentanone	ND	50.0	47.4	95	50.0	49.8	100	5	60-135	30
Acetone	ND	50.0	38.5	77	50.0	40.4	81	5	40-140	30
Benzene	ND	10.0	9.99	100	10.0	10.6	106	6	80-120	30
Bromodichloromethane	ND	10.0	9.41	94	10.0	10.1	101	7	75-120	30
Bromoform	ND	10.0	8.74	87	10.0	9.60	96	9	70-130	30
Bromomethane	ND	10.0	7.93	79	10.0	8.19	82	3	30-145	30
Carbon Tetrachloride	ND	10.0	9.85	99	10.0	10.6	106	7	65-140	30
Chlorobenzene	ND	10.0	9.99	100	10.0	10.7	107	7	80-120	30
Chloroethane	ND	10.0	8.61	86	10.0	9.35	93	8	60-135	30
Chloroform	ND	10.0	9.62	96	10.0	10.1	101	5	65-135	30
Chloromethane	ND	10.0	9.62	96	10.0	10.3	103	7	40-125	30
cis-1,2-Dichloroethene	ND	10.0	8.84	88	10.0	9.33	93	5	70-125	30
cis-1,3-Dichloropropene	ND	10.0	9.97	100	10.0	10.5	105	5	70-130	30
Dibromochloromethane	ND	10.0	9.42	94	10.0	9.92	99	5	60-135	30
Ethylbenzene	ND	10.0	9.82	98	10.0	10.5	105	7	75-125	30
Methylene Chloride	ND	10.0	9.77	98	10.0	10.3	103	6	55-140	30
m/p-Xylenes	ND	20.0	19.5	97	20.0	20.8	104	7	75-130	30
o-Xylene	ND	10.0	9.80	98	10.0	10.4	104	6	75-130	30
Styrene	ND	10.0	9.05	90	10.0	9.65	97	6	65-135	30
Tetrachloroethene	ND	10.0	9.62	96	10.0	10.1	101	5	45-150	30
Toluene	ND	10.0	9.85	98	10.0	10.4	104	5	75-120	30
Trans-1,2-Dichloroethene	ND	10.0	9.61	96	10.0	9.97	100	4	60-140	30
Trans-1,3-Dichloropropene	ND	10.0	9.84	98	10.0	10.5	105	6	55-140	30
Trichloroethene	ND	10.0	10.2	102	10.0	10.8	108	5	70-125	30
Vinyl Chloride	ND	10.0	9.48	95	10.0	10.8	108	13	50-145	30

SURROGATE PARAMETER	SPIKE AMT (ug/L)	MS RSLT (ug/L)	MS % REC	SPIKE AMT (ug/L)	MSD RSLT (ug/L)	MSD % REC	QC LIMIT (%)
1,2-Dichloroethane-d4	10.0	9.01	90	10.0	9.28	93	70-120
4-Bromofluorobenzene	10.0	9.94	99	10.0	10.3	103	75-120
Toluene-d8	10.0	10.0	100	10.0	10.1	101	85-120

Figure 9: TYPICAL CASE NARRATIVE

CASE NARRATIVE

Client : XYZ, INC.

Project : CLEAN WATER PROJECT

SDG : 11D289

METHOD 5030B/8260B
VOLATILE ORGANICS BY GC/MS

A total of three (3) water samples were received on 04/29/11 for Volatile Organics by GC/MS analysis, Method 5030B/8260B in accordance with USEPA SW-846, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods and 2009 GW QAPP.

Holding Time
Samples were analyzed within the prescribed holding time.

Instrument Performance and Calibration
Instrument tune check was performed prior to calibration. Instrument mass ratios were within specification. Multi-calibration points were generated to establish initial calibration (ICAL). ICAL was verified using secondary source (ICV). Continuing calibration (CCV) was carried on at a frequency required by the project. All project calibration requirements were satisfied. Refer to calibration summary forms for ICAL, ICV and CCV for details.

Method Blank
Method blank was analyzed at the frequency required by the project. For this SDG, one method blank was analyzed with the samples. Result was compliant to project requirement.

Lab Control Sample
A set of LCS/LCD was analyzed with the samples in this SDG.
Percent recoveries for VO06D35L/C were all within QC limits.

Matrix QC Sample
A set of MS/MSD was analyzed with the samples in this SDG.
Percent recoveries for D289-01M/S were within project QC limits.

Surrogate
Surrogates were added on QC and field samples. Surrogate recoveries were within project QC limits.

Sample Analysis
Samples were analyzed according to prescribed analytical procedures. All project requirements were met otherwise anomalies were discussed within the associated QC parameter.

Appendix 1: SUMMARY OF QUALITY CONTROL PROCEDURES

QC PROCEDURE	FREQUENCY	ACCEPTANCE CRITERIA	CORRECTIVE ACTION	1st Rvw	2nd Rvw
Check of mass spectral ion intensities using BFB	Prior to initial calibration and calibration verification	Refer to criteria listed in Table 6	Retune instrument and verify		
Multi point Initial Calibration(ICAL) minimum of 6 points	Initially; as needed	SPCCs : RF ≥ 0.1 for Bromoform, Chloromethane and 1,1-Dichloroethane RF ≥ 0.3 for Chlorobenzene and 1,1,2,2-Tetrachloroethane CCCs: Chloroform, 1,1-DCE, 1,2-DCP, Ethylbenzene, Toluene and Vinyl Chloride. CCCs: RSD ≤ 30% and one option below: 1). For analytes with RSD ≤ 15%, use RRFm 2). For analytes with RSD>15% and r ≥0..995, use either Inverse Weighting Factor or Linear Least Squares 3). For analytes with RSD>15% and COD ≥0.99, use non-linear regression (6 pts for second order, 7 pts for third order).	Check for outliers. Otherwise, optimize the instrument then repeat initial calibration.		
Initial calibration verification (ICV)	After initial calibration	In the absence of PSR All analytes within ± 20% of expected value except for the following compounds due to erratic chromatographic behavior: Bromomethane, Chloroethane, Chloromethane, Dichlorodifluoromethane within ± 35% of expected value.	Verify second source standard. Prepare fresh standard and rerun ICV. If that fails, Optimize instrument and repeat ICAL.		
Evaluation of relative retention times (RRT)	Each sample	Within ± 0.06 RRT units	Correct the problem then reanalyze all samples analyzed since the last retention time check		
Continuing Calibration verification (CCV)	Daily, before sample analysis and every 12 hours of analysis time	SPCCs: Min. RF same as ICAL CCC : %Diff ≤ 20% (when using RFs) or drift (when using least squares regression or non-linear calibration)	Correct the problem then repeat initial calibration		
Internal Standard (IS)	All samples	Retention time ± 30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard	Inspect mass spectrometer and GC for malfunctions; mandatory reanalysis of samples analyzed while system was malfunctioning		
Method blank (MB)	One per preparation batch	No analytes detected >½ LOQ	Rule out instrument contamination by re-analyzing the MB. If problem persist refer to PSR. In the absence of PSR, report NDs and results >10X of the MB concentration. Otherwise, cure contamination source, re-prep and re-analyze method blank and all associated samples.		
LCS	One LCS per preparation	Within project QC Limits	Re-prep and re-analyze the LCS and all associated samples		
MS/MSD	One MS/MSD per every 20 project samples per matrix	Within project QC Limits	Check if sample was properly spiked. If indicative of matrix interference, discuss in case narrative, otherwise re-prep and re-analyze the sample		
Surrogate	Every Sample, MB, LCS, MS/MSD, DCC	Within project QC Limits	Correct the problem then re-analyze		
Comments: Refer to PSR for Flagging Criteria. Report values between LOD and LOQ.			Reviewed by:		
			Date:		

Appendix 2: DEMONSTRATION OF CAPABILITY FOR 5 ml

Method 8260B	VO06D35L	VO06D35C	D289-01M	D289-01S	Exp.Value	Ave.Conc.	Ave. Rec	SD	RSD	LQCL	UQCL	
PARAMETER	RDW649	RDW650	RDW658	RDW659	ug/L	ug/L	%	ug/L	%	%	%	Comments
1,1,1,2-Tetrachloroethane	9.5083	10.4696	9.5189	10.0153	10	9.878025	99	0.46	4.7	70	130	Passed
1,1,1-Trichloroethane	8.752	9.7575	8.8464	9.4997	10	9.2139	92	0.492	5.3	70	130	Passed
1,1,2,2-Tetrachloroethane	10.1074	11.9899	10.524	11.5197	10	11.03525	110	0.87	7.9	70	130	Passed
1,1,2-Trichloro-1,2,2-trifluoroethane	10.2533	10.8944	9.9936	10.259	10	10.35008	104	0.383	3.7	60	140	Passed
1,1,2-Trichloroethane	9.777	11.4539	10.1451	10.858	10	10.5585	106	0.747	7.1	70	130	Passed
1,1-Dichloroethane	9.7087	10.6365	9.9411	10.428	10	10.17858	102	0.428	4.2	70	130	Passed
1,1-Dichloroethene	10.169	10.6763	10.1887	10.4837	10	10.37943	104	0.245	2.4	60	130	Passed
1,1-Dichloropropene	10.737	11.3046	10.5248	11.0132	10	10.8949	109	0.339	3.1	70	130	Passed
1,2,3-Trichlorobenzene	9.3484	10.5473	9.175	10.5569	10	9.9069	99	0.748	7.6	60	130	Passed
1,2,3-Trichloropropane	9.6797	11.3921	9.8967	11.0707	10	10.5098	105	0.848	8.1	70	130	Passed
1,2,4-Trichlorobenzene	9.8175	10.7492	9.3574	10.8335	10	10.1894	102	0.721	7.1	70	130	Passed
1,2,4-Trimethylbenzene	9.946	10.5598	9.647	10.878	10	10.2577	103	0.562	5.5	60	140	Passed
1,2-Dibromo-3-chloropropane	8.3842	10.122	8.5716	9.6826	10	9.1901	92	0.845	9.2	70	130	Passed
1,2-Dibromoethane	9.2217	10.5961	9.4828	10.1388	10	9.85985	99	0.624	6.3	70	130	Passed
1,2-Dichlorobenzene	9.9923	11.0144	9.9735	11.1367	10	10.52923	105	0.633	6.0	70	130	Passed
1,2-Dichloroethane	9.823	11.0767	10.0605	10.9087	10	10.46723	105	0.618	5.9	70	130	Passed
1,2-Dichloropropane	10.5484	11.7184	10.8308	11.4227	10	11.13008	111	0.535	4.8	70	130	Passed
1,3,5-Trimethylbenzene	9.7476	10.2145	9.4702	10.5038	10	9.984025	100	0.463	4.6	70	130	Passed
1,3-Dichlorobenzene	9.9353	10.8092	9.7147	10.8681	10	10.33183	103	0.593	5.7	70	130	Passed
1,3-Dichloropropane	9.9962	11.4742	10.3975	11.1105	10	10.7446	107	0.67	6.2	70	130	Passed
1,4-Dichlorobenzene	10.0009	10.8729	9.9016	11.0321	10	10.45188	105	0.583	5.6	70	130	Passed
1-Chlorohexane	10.6624	11.4574	10.5259	11.1851	10	10.9577	110	0.438	4.0	70	130	Passed
2,2-Dichloropropane	7.7034	8.703	7.3123	7.8865	10	7.9013	79	0.586	7.4	60	140	Passed
2-Butanone	43.76	53.1037	45.9633	47.575	50	47.6005	95	3.988	8.4	60	140	Passed
2-Chlorotoluene	10.317	10.4091	9.8953	11.053	10	10.4186	104	0.478	4.6	70	130	Passed
2-Hexanone	47.1006	56.9767	49.3731	52.7989	50	51.56233	103	4.303	8.3	60	140	Passed
4-Chlorotoluene	9.6058	10.952	9.7545	10.8425	10	10.2887	103	0.707	6.9	70	130	Passed
4-Methyl-2-pentanone	44.8712	54.2842	47.3516	49.8041	50	49.07778	98	4.013	8.2	60	140	Passed
Acetone	39.2273	45.1546	38.5256	40.377	50	40.82113	82	2.988	7.3	60	140	Passed
Acrolein	4.8199	5.6406	5.2049	5.6221	10	5.321875	53	0.39	7.3	30	160	Passed
Acrylonitrile	42.7249	50.0476	45.5451	46.8581	50	46.29393	93	3.039	6.6	60	150	Passed
Benzene	9.9808	10.712	9.9919	10.6051	10	10.32245	103	0.391	3.8	70	130	Passed
Benzyl chloride	9.7592	11.2602	8.6451	9.4586	10	9.780775	98	1.093	11.2	50	150	Passed

Appendix 2: DEMONSTRATION OF CAPABILITY FOR 5 ml

Method 8260B	VO06D35L	VO06D35C	D289-01M	D289-01S	Exp.Value	Ave.Conc.	Ave. Rec	SD	RSD	LQCL	UQCL	
PARAMETER	RDW649	RDW650	RDW658	RDW659	ug/L	ug/L	%	ug/L	%	%	%	Comments
Bromobenzene	9.1769	9.9944	9.1166	10.0527	10	9.58515	96	0.507	5.3	70	130	Passed
Bromochloromethane	9.9802	11.3457	10.5614	11.2986	10	10.79648	108	0.652	6.0	70	130	Passed
Bromodichloromethane	9.0969	10.3325	9.4122	10.1384	10	9.745	97	0.586	6.0	70	130	Passed
Bromoform	8.9401	10.0014	8.7352	9.5952	10	9.317975	93	0.585	6.3	60	130	Passed
Bromomethane	8.0326	8.6113	7.9312	8.1892	10	8.191075	82	0.3	3.7	50	130	Passed
Carbon disulfide	8.8275	9.3575	8.7675	9.2025	10	9.03875	90	0.287	3.2	50	130	Passed
Carbon tetrachloride	9.9407	10.5379	9.8502	10.5816	10	10.2276	102	0.386	3.8	70	130	Passed
Chlorobenzene	9.9594	10.9841	9.9948	10.6988	10	10.40928	104	0.513	4.9	70	130	Passed
Chloroethane	8.6156	9.049	8.6116	9.3487	10	8.906225	89	0.359	4.0	60	130	Passed
Chloroform	9.2078	10.2856	9.6246	10.0824	10	9.8001	98	0.482	4.9	70	130	Passed
Chloromethane	10.1544	10.5301	9.6243	10.3323	10	10.16028	102	0.389	3.8	60	140	Passed
cis-1,2-Dichloroethene	8.6405	9.5371	8.8439	9.3271	10	9.08715	91	0.416	4.6	70	130	Passed
cis-1,3-Dichloropropene	9.87	10.9577	9.9691	10.5233	10	10.33003	103	0.508	4.9	70	130	Passed
Dibromochloromethane	9.3312	10.5939	9.4192	9.918	10	9.815575	98	0.58	5.9	70	130	Passed
Dibromomethane	9.8126	11.3836	10.2117	10.9383	10	10.58655	106	0.707	6.7	70	130	Passed
Dichlorodifluoromethane	10.7781	10.8065	10.5056	11.089	10	10.7948	108	0.238	2.2	50	140	Passed
Dichlorofluoromethane	9.2152	10.041	9.1006	9.2372	10	9.3985	94	0.432	4.6	70	130	Passed
Ethyl methacrylate	9.4524	11.362	9.8887	10.5262	10	10.30733	103	0.83	8.1	70	130	Passed
Ethylbenzene	9.7771	10.7006	9.8224	10.5229	10	10.20575	102	0.475	4.7	50	150	Passed
Hexachlorobutadiene	9.552	9.924	8.9673	10.2288	10	9.668025	97	0.543	5.6	70	130	Passed
Iodomethane	9.3	10.2454	9.4449	9.9418	10	9.733025	97	0.438	4.5	50	150	Passed
Isopropyl ether (DIPE)	10.088	11.4344	10.473	10.9829	10	10.74458	107	0.588	5.5	70	130	Passed
Isopropylbenzene	10.9965	11.6004	10.6444	11.7425	10	11.24595	112	0.515	4.6	70	130	Passed
Methylene chloride	9.2122	10.3536	9.7659	10.3252	10	9.914225	99	0.541	5.5	70	130	Passed
m-Xylene & p-Xylene	19.4382	21.0217	19.4539	20.8295	20	20.18583	101	0.858	4.3	70	130	Passed
Naphthalene	9.7346	11.2906	9.613	11.1325	10	10.44268	104	0.892	8.5	60	130	Passed
n-Butylbenzene	10.4068	11.0978	10.0346	11.4373	10	10.74413	107	0.638	5.9	70	130	Passed
n-Propylbenzene	10.4484	11.0059	10.187	11.2659	10	10.7268	107	0.496	4.6	70	130	Passed
o-Xylene	9.6959	10.4797	9.8033	10.3952	10	10.09353	101	0.401	4.0	70	130	Passed
p-Isopropyltoluene	9.9613	10.5784	9.7653	10.8551	10	10.29003	103	0.512	5.0	70	130	Passed
sec-Butylbenzene	10.6725	11.1613	10.2423	11.3846	10	10.86518	109	0.511	4.7	70	130	Passed
Styrene	9.0809	10.0425	9.047	9.6541	10	9.456125	95	0.48	5.1	70	130	Passed
tert-Amyl methyl ether (TAME)	9.2609	11.1109	9.746	10.2632	10	10.09525	101	0.791	7.8	70	130	Passed

Appendix 2: DEMONSTRATION OF CAPABILITY FOR 5 ml

Method 8260B	VO06D35L	VO06D35C	D289-01M	D289-01S	Exp.Value	Ave.Conc.	Ave. Rec	SD	RSD	LQCL	UQCL	
PARAMETER	RDW649	RDW650	RDW658	RDW659	ug/L	ug/L	%	ug/L	%	%	%	Comments
tert-Butyl alcohol	48.0053	48.4198	43.1518	41.0816	50	45.16463	90	3.623	8.0	50	150	Passed
tert-Butyl ethyl ether (ETBE)	9.5166	11.2064	10.0753	10.6205	10	10.3547	104	0.725	7.0	70	130	Passed
tert-Butyl methyl ether (MTBE)	9.3299	11.275	9.8715	10.4256	10	10.2255	102	0.83	8.1	70	130	Passed
tert-Butylbenzene	10.2185	10.6527	9.8574	10.7365	10	10.36628	104	0.408	3.9	70	130	Passed
Tetrachloroethene	9.848	10.4231	9.6238	10.1358	10	10.00768	100	0.347	3.5	70	130	Passed
Tetrahydrofuran	10.0864	12.3659	10.7485	11.6038	10	11.20115	112	0.994	8.9	50	150	Passed
Toluene	9.7939	10.5433	9.8464	10.3812	10	10.1412	101	0.377	3.7	70	130	Passed
trans-1,2-Dichloroethene	9.4023	10.1055	9.6128	9.9722	10	9.7732	98	0.323	3.3	70	130	Passed
trans-1,3-Dichloropropene	9.67	10.944	9.8428	10.4849	10	10.23543	102	0.588	5.7	70	130	Passed
trans-1,4-Dichloro-2-butene	8.1623	8.2881	7.8517	7.7961	10	8.02455	80	0.238	3.0	50	150	Passed
Trichloroethene	10.3992	11.1892	10.2098	10.7693	10	10.64188	106	0.433	4.1	70	130	Passed
Trichlorofluoromethane	9.611	9.9623	9.4192	9.9575	10	9.7375	97	0.268	2.8	60	140	Passed
Vinyl acetate	10.5397	12.4152	10.2755	10.967	10	11.04935	110	0.954	8.6	50	150	Passed
Vinyl chloride	10.141	10.3507	9.4766	10.7844	10	10.18818	102	0.545	5.3	60	140	Passed
Dibromofluoromethane	9.3479	9.3709	9.4539	9.3511	10	9.38095	94	0.05	0.5	70	130	Passed
1,2-Dichloroethane-d4	8.8152	9.2399	9.0094	9.2763	10	9.0852	91	0.215	2.4	70	130	Passed
4-Bromofluorobenzene	10.1116	9.9748	9.9406	10.3418	10	10.0922	101	0.182	1.8	70	130	Passed
Toluene-d8	10.1317	9.9846	10.042	10.1426	10	10.07523	101	0.075	0.7	70	130	Passed

Appendix 3: DEMONSTRATION OF CAPABILITY FOR 25 ml

METHOD 8260B	VO02E17L	VO02E17C	VO02E18L	VO02E18C	Exp.Value	Ave.Conc.	Ave. Rec	SD	RSD	LQCL	UQCL	Comments
PARAMETER	REP218	REP219	REP240	REP241	ug//Kg	ug//Kg	%	ug//Kg	%	%	%	
1,1,1,2-Tetrachloroethane	52.4192	51.3712	52.2568	51.2415	50	51.82218	104	0.602	1.2	70	130	Passed
1,1,1-Trichloroethane	51.1651	50.6377	50.3729	49.6661	50	50.46045	101	0.624	1.2	70	130	Passed
1,1,2,2-Tetrachloroethane	52.2787	52.5148	49.9376	51.3172	50	51.51208	103	1.17	2.3	70	130	Passed
1,1,2-Trichloro-1,2,2-trifluoroethane	50.8567	50.1855	52.4282	49.93	50	50.8501	102	1.122	2.2	60	140	Passed
1,1,2-Trichloroethane	51.5361	50.9497	51.0105	50.7311	50	51.05685	102	0.341	0.7	70	130	Passed
1,1-Dichloroethane	51.0991	50.6098	51.149	50.4971	50	50.83875	102	0.333	0.7	70	130	Passed
1,1-Dichloroethene	50.423	49.0691	51.7461	48.8568	50	50.02375	100	1.342	2.7	60	130	Passed
1,1-Dichloropropene	51.438	50.1032	51.0467	49.7738	50	50.59043	101	0.781	1.5	70	130	Passed
1,2,3-Trichlorobenzene	51.5357	48.7315	51.956	48.8125	50	50.25893	101	1.726	3.4	50	140	Passed
1,2,3-Trichloropropane	53.2052	51.9622	50.5634	52.0856	50	51.9541	104	1.083	2.1	60	140	Passed
1,2,4-Trichlorobenzene	51.2648	49.2116	51.6211	47.8161	50	49.9784	100	1.79	3.6	60	130	Passed
1,2,4-Trimethylbenzene	49.4281	48.786	48.3459	48.0109	50	48.64273	97	0.612	1.3	70	130	Passed
1,2-Dibromo-3-chloropropane	49.2155	48.4181	49.812	49.6919	50	49.28438	99	0.632	1.3	60	140	Passed
1,2-Dibromoethane	49.6161	48.8917	48.862	48.8813	50	49.06278	98	0.369	0.8	70	130	Passed
1,2-Dichlorobenzene	51.3944	49.9236	51.2638	50.0017	50	50.64588	101	0.791	1.6	70	130	Passed
1,2-Dichloroethane	52.5465	51.4734	51.415	51.26	50	51.67373	103	0.589	1.1	70	130	Passed
1,2-Dichloropropane	51.253	49.8221	50.3379	49.7001	50	50.27828	101	0.706	1.4	70	130	Passed
1,3,5-Trimethylbenzene	46.9267	46.7395	46.4795	45.6667	50	46.4531	93	0.555	1.2	70	140	Passed
1,3-Dichlorobenzene	50.9151	50.2315	50.306	49.0675	50	50.13003	100	0.772	1.5	70	130	Passed
1,3-Dichloropropane	52.6425	51.1206	51.0134	50.8751	50	51.4129	103	0.826	1.6	70	130	Passed
1,4-Dichlorobenzene	52.2437	50.822	51.9834	49.6447	50	51.17345	102	1.192	2.3	70	130	Passed
1,4-Dioxane	1129.452	1124.151	1099.757	1088.391	1000	1110.438	111	19.58	1.8	50	150	Passed
1-Chlorohexane	51.8271	51.3713	52.4175	50.992	50	51.65198	103	0.614	1.2	70	130	Passed
2,2-Dichloropropane	49.349	49.6296	47.8528	48.4183	50	48.81243	98	0.823	1.7	70	140	Passed
2-Butanone	255.3343	262.8706	248.5028	258.5945	250	256.3256	103	6.06	2.4	60	140	Passed
2-Chlorotoluene	45.6521	44.9969	50.7576	48.8317	50	47.55958	95	2.711	5.7	70	130	Passed
2-Hexanone	276.9919	284.0704	269.5532	278.4803	250	277.274	111	5.982	2.2	60	140	Passed
4-Chlorotoluene	55.285	53.0416	45.5138	46.5524	50	50.0982	100	4.801	9.6	60	140	Passed
4-Methyl-2-pentanone	268.9367	275.6233	260.4184	271.7804	250	269.1897	108	6.458	2.4	60	140	Passed
Acetone	266.7425	276.013	261.1467	269.7677	250	268.4175	107	6.196	2.3	60	140	Passed
Acetonitrile	527.7739	530.2129	530.3376	529.9726	500	529.5743	106	1.21	0.2	50	150	Passed
Acrolein	268.735	276.3886	259.7895	255.7614	250	265.1686	106	9.238	3.5	50	150	Passed
Acrylonitrile	264.9375	266.8656	254.5779	267.0142	250	263.3488	105	5.923	2.2	70	130	Passed

Appendix 3: DEMONSTRATION OF CAPABILITY FOR 25 ml

METHOD 8260B	VO02E17L	VO02E17C	VO02E18L	VO02E18C	Exp.Value	Ave.Conc.	Ave. Rec	SD	RSD	LQCL	UQCL	Comments
PARAMETER	REP218	REP219	REP240	REP241	ug//Kg	ug//Kg	%	ug//Kg	%	%	%	
Benzene	49.6084	48.2028	49.4734	48.2354	50	48.88	98	0.765	1.6	70	130	Passed
Bromobenzene	49.2332	47.92	47.1073	47.0773	50	47.83445	96	1.011	2.1	70	130	Passed
Bromochloromethane	50.58	49.9253	49.7477	49.436	50	49.92225	100	0.483	1.0	70	130	Passed
Bromodichloromethane	51.4357	50.5465	50.1899	50.0959	50	50.567	101	0.611	1.2	70	130	Passed
Bromoform	54.7558	54.9519	52.4296	53.6558	50	53.94828	108	1.162	2.2	60	130	Passed
Bromomethane	50.7657	50.4967	47.6119	46.9342	50	48.95213	98	1.962	4.0	60	130	Passed
Carbon disulfide	50.5425	50.3368	50.8176	50.2367	50	50.4834	101	0.257	0.5	30	150	Passed
Carbon tetrachloride	51.5147	50.1934	50.5655	49.55	50	50.4559	101	0.821	1.6	70	130	Passed
Chlorobenzene	52.8899	52.1532	53.2434	51.6393	50	52.48145	105	0.722	1.4	70	130	Passed
Chloroethane	51.3359	50.2276	53.028	51.4934	50	51.52123	103	1.152	2.2	60	140	Passed
Chloroform	52.0133	50.8125	51.4635	50.5115	50	51.2002	102	0.672	1.3	70	130	Passed
Chloromethane	50.2006	48.4193	50.3726	48.8979	50	49.4726	99	0.963	1.9	50	130	Passed
cis-1,2-Dichloroethene	47.5744	46.2471	47.1082	46.4113	50	46.83525	94	0.618	1.3	70	130	Passed
cis-1,3-Dichloropropene	53.7815	52.7956	52.3745	51.7345	50	52.67153	105	0.859	1.6	70	130	Passed
Dibromochloromethane	52.6719	51.7987	52.2574	51.9668	50	52.1737	104	0.382	0.7	70	130	Passed
Dibromomethane	51.0647	50.3774	49.909	49.8319	50	50.29575	101	0.566	1.1	70	130	Passed
Dichlorodifluoromethane	48.8432	48.4798	45.498	43.1411	50	46.49053	93	2.689	5.8	50	140	Passed
Dichlorofluoromethane	49.9978	48.304	50.4884	48.9577	50	49.43698	99	0.989	2.0	70	130	Passed
Ethyl methacrylate	50.8442	50.7512	48.5706	50.0247	50	50.04768	100	1.051	2.1	50	150	Passed
Ethylbenzene	51.066	50.2567	51.0384	49.5239	50	50.47125	101	0.735	1.5	70	130	Passed
Hexachlorobutadiene	46.1267	44.5982	47.9921	43.3364	50	45.51335	91	2.008	4.4	50	150	Passed
Iodomethane	53.7893	53.1952	55.0696	53.151	50	53.80128	108	0.894	1.7	50	150	Passed
Isopropyl ether (DIPE)	49.4942	48.5712	49.2275	48.1491	50	48.8605	98	0.613	1.3	70	130	Passed
Isopropylbenzene	53.0522	52.1758	50.8283	50.6646	50	51.68023	103	1.138	2.2	70	140	Passed
Methylene chloride	49.4828	48.9647	50.2532	48.9006	50	49.40033	99	0.625	1.3	60	130	Passed
m-Xylene & p-Xylene	101.219	99.0239	101.2423	97.7876	100	99.8182	100	1.707	1.7	70	130	Passed
Naphthalene	54.1273	52.283	54.042	51.84	50	53.07308	106	1.182	2.2	60	140	Passed
n-Butylbenzene	49.2587	47.9773	49.3209	46.8857	50	48.36065	97	1.162	2.4	60	140	Passed
n-Propylbenzene	51.095	50.2901	49.4566	49.045	50	49.97168	100	0.911	1.8	70	140	Passed
o-Xylene	51.7325	50.9411	52.0994	50.5872	50	51.34005	103	0.697	1.4	70	130	Passed
p-Isopropyltoluene	50.5518	48.6666	49.4591	47.4904	50	49.04198	98	1.291	2.6	70	130	Passed
sec-Butylbenzene	50.7742	49.516	50.4797	49.0185	50	49.9471	100	0.82	1.6	70	140	Passed
Styrene	42.96	48.563	45.9849	42.041	50	44.88723	90	2.974	6.6	70	130	Passed

Appendix 3: DEMONSTRATION OF CAPABILITY FOR 25 ml

METHOD 8260B	VO02E17L	VO02E17C	VO02E18L	VO02E18C	Exp.Value	Ave.Conc.	Ave. Rec	SD	RSD	LQCL	UQCL	Comments
PARAMETER	REP218	REP219	REP240	REP241	ug//Kg	ug//Kg	%	ug//Kg	%	%	%	
tert-Amyl methyl ether (TAME)	51.9913	51.4366	51.7547	51.0579	50	51.56013	103	0.405	0.8	70	130	Passed
tert-Butyl alcohol	274.3094	284.1807	248.5132	264.3997	250	267.8508	107	15.21	5.7	50	140	Passed
tert-Butyl ethyl ether (ETBE)	50.7507	50.5641	50.6042	50.3283	50	50.56183	101	0.175	0.3	70	130	Passed
tert-Butyl methyl ether (MTBE)	50.6278	50.1673	50.2862	49.9534	50	50.25868	101	0.282	0.6	70	130	Passed
tert-Butylbenzene	51.5985	48.6531	49.486	49.1418	50	49.71985	99	1.298	2.6	70	130	Passed
Tetrachloroethene	50.327	49.0728	49.9859	48.6591	50	49.5112	99	0.777	1.6	70	130	Passed
Tetrahydrofuran	51.0772	51.1159	49.1878	49.8853	50	50.31655	101	0.945	1.9	50	150	Passed
Toluene	49.8848	49.0291	49.4586	48.7004	50	49.26823	99	0.515	1.0	70	130	Passed
trans-1,2-Dichloroethene	48.3293	47.4877	48.4833	47.2825	50	47.8957	96	0.599	1.3	70	130	Passed
trans-1,3-Dichloropropene	54.609	54.2644	53.3571	53.0207	50	53.8128	108	0.747	1.4	70	130	Passed
trans-1,4-Dichloro-2-butene	52.2082	51.629	49.5378	50.8515	50	51.05663	102	1.155	2.3	50	150	Passed
Trichloroethene	52.4215	51.1961	51.639	50.35	50	51.40165	103	0.865	1.7	70	130	Passed
Trichlorofluoromethane	49.6853	48.6762	54.2868	51.4255	50	51.01845	102	2.457	4.8	70	140	Passed
Vinyl acetate	50.2045	53.8381	52.9479	49.0962	50	51.52168	103	2.237	4.3	40	160	Passed
Vinyl chloride	46.6269	45.463	47.9698	46.1026	50	46.54058	93	1.065	2.3	50	130	Passed
Dibromofluoromethane	48.1003	47.8254	48.0971	49.0229	50	48.26143	97	0.524	1.1	70	130	Passed
1,2-Dichloroethane-d4	48.3851	48.3457	48.1298	49.1481	50	48.50218	97	0.445	0.9	60	140	Passed
4-Bromofluorobenzene	49.2158	49.1646	47.8853	48.4132	50	48.66973	97	0.639	1.3	70	130	Passed
Toluene-d8	49.564	49.1062	49.4689	49.622	50	49.44028	99	0.231	0.5	70	130	Passed

8260FA: **ANALYTICAL RUN LOG**

EMAX LABORATORIES, INC.

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ANALYSIS LOG FOR VOLATILES

SOP ☐ EMAX-8260 Rev.No. __ ☐ EMAX-524.2 Rev.No. __ ☐ EMAX-624 Rev.No. __ ☐ EMAX-8260SIM Rev.No. __ ☐ EMAX-TCPSIM Rev.No. __ ☐ EMAX-M8260SIM Rev.No. __ ☐

Start Date: ☐ 5-mL Purge ☐ 10-mL Purge ☐ 25-mL Purge Book # A06 -048

BATCH _____

Sample Prep. ID	Data File Name	Lab Sample ID	Sample Amount	DF	Matrix W pH <2	Matrix W Cl <5ppm	Matrix S	Notes
01								
02								
03								
04								
05								
06								
07								
08								
09								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								

Instrument No.	06
INITIAL CALIBRATION REFERENCE	
DATE	
ICAL ID	

STANDARDS

NAME	ID	Amount (µL)	Conc. (mg/L)
DCC			
DCC			
DCC			
DCC			
BFB			
IS/SURR.			
ICV/LCS			
ICV/LCS			
ICV/LCS			
ICV/LCS			
DATA FILE FOLDER			

Electronic Data Archival

Location	Date
HPCHEM_VOA/TO06	

Comments: _____

Analyzed By: _____

Date Disposed: _____

Disposed By: _____

8260FM: INSTRUMENT MAINTENANCE LOG

EMAX LABORATORIES, INC.

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INSTRUMENT MAINTENANCE LOG

Instrument No: 05 Month: Year: 201_ Book # : MD3-005

DATE						
Bake Trap (210°C-260°C)						
Column Head Pressure (2-60 psi)						
Injector Port Temperature (160°C-220°C)						
Interface Temperature (250°C-280°C)						
Verify Computer Date and Time						
Check Gas Pressure (Daily)						
Check IS/Surrogate auto injection vial as appropriate (Daily)						
Check the foreline pump oil level (Weekly)						
AutoTune the MSD (As needed)						
Analyst's initial						
Trouble Shooting						
Problem(s) Encountered						
Return-to-Control (Analyst Initial)						

Code	Problems Encountered	Code	Corrrective Action

Appendix C
Field Standard Operating Procedures

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Equipment Decontamination

Procedure 3-06

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) describes methods of equipment decontamination, used for activities where samples for chemical analysis are collected or where equipment will need cleaning before leaving a site or before use in subsequent activities.

1.2 This procedure is the Program-approved professional guidance for work performed by AECOM-Envirocon Joint Venture (AEJV) for task orders issued under the Performance Based Environmental Multiple Award Contract Number N62473-11-D-2231.

1.3 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review.

2.0 Safety

It is the responsibility of the **Site Safety and Health Officer (SSHO)** to set up the site zones (i.e., exclusion, transition, and clean) and decontamination areas. Generally the decontamination area is located within the transition zone, upwind of intrusive activities, and serves as the washing area for both personnel and equipment to minimize the spread of contamination into the clean zone. Typically, for equipment, a series of buckets are set up on a visqueen-lined bermed area. Separate spray bottles containing cleaning solvents as described in this procedure or the project Work Plan (WP) and distilled water are used for final rinsing of equipment. Depending on the nature of the hazards and the site location, decontamination of heavy equipment, such as augers, pump drop pipe, and vehicles, may be accomplished using a variety of techniques.

All **Field Personnel** responsible for equipment decontamination must adhere to the site-specific health and safety plan (SSHSP) and must wear the personal protective equipment (PPE) specified in the SSHSP. Generally this includes, at a minimum, steel-toed boots, safety glasses, American National Standards Institute (ANSI)-standard hard hats, and hearing protection (if heavy equipment is in operation). Air monitoring by the **SSHO** may result in an upgrade to the use of respirators and cartridges in the decontamination area; therefore, this equipment must be available on site. If safe alternatives are not achievable, discontinue site activities immediately.

In addition to the aforementioned precautions, the following sections describe safe work practices that will be employed.

2.1 **Chemical Hazards associated with Equipment Decontamination**

- Avoid skin contact with and/or incidental ingestion of decontamination solutions and water.
- Utilize PPE as specified in the site-specific SSHSP to maximize splash protection.
- Refer to material safety data sheets, safety personnel, and/or consult sampling personnel regarding appropriate safety measures (i.e., handling, PPE including skin and respiratory).
- Take the necessary precautions when handling detergents and reagents.

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2.2 Physical Hazards associated with Equipment Decontamination

- To avoid possible back strain, it is recommended to raise the decontamination area 1 to 2 feet above ground level.
- To avoid heat stress, over exertion, and exhaustion, it is recommended to rotate equipment decontamination among all site personnel.
- Take necessary precautions when handling field sampling equipment.

3.0 Terms and Definitions

None.

4.0 Training and Qualifications

4.1 The **Project Manager (PM)** is responsible for ensuring that decontamination activities comply with this procedure. The **PM** is responsible for ensuring that all personnel involved in equipment decontamination shall have the appropriate education, experience, and training to perform their assigned tasks.

4.2 The **Program Quality Control Manager** is responsible for ensuring overall compliance with this procedure.

4.3 The **Field Manager** is responsible for ensuring that all field equipment is decontaminated according to this procedure.

4.4 All **Field Personnel** are responsible for the implementation of this procedure.

5.0 Procedure

Decontamination of equipment used in soil/sediment sampling, groundwater monitoring, well drilling and well development, as well as equipment used to sample groundwater, surface water, sediment, waste, wipe, asbestos, and unsaturated zone, is necessary to prevent cross-contamination and to maintain the highest integrity possible in collected samples. Planning a decontamination program requires consideration of the following factors:

- Location where the decontamination procedures will be conducted
- Types of equipment requiring decontamination
- Frequency of equipment decontamination
- Cleaning technique and types of cleaning solutions appropriate to the contaminants of concern
- Method for containing the residual contaminants and wash water from the decontamination process
- Use of a quality control measure to determine the effectiveness of the decontamination procedure

The following subsections describe standards for decontamination, including the frequency of decontamination, cleaning solutions and techniques, containment of residual contaminants and cleaning solutions, and effectiveness.

5.1 Decontamination Area

Select an appropriate location for the decontamination area at a site based on the ability to control access to the area, the ability to control residual material removed from equipment, the need to store clean equipment, and the ability to restrict access to the area being investigated. Locate the decontamination area an adequate distance away and upwind from potential contaminant sources to avoid contamination of clean equipment.

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5.2 Types of Equipment

Drilling equipment that must be decontaminated includes drill bits, auger sections, drill-string tools, drill rods, split barrel samplers, tremie pipes, clamps, hand tools, and steel cable. Decontamination of monitoring well development and groundwater sampling equipment includes submersible pumps, bailers, interface probes, water level meters, bladder pumps, airlift pumps, peristaltic pumps, and lysimeters. Other sampling equipment that requires decontamination includes, but is not limited to, hand trowels, hand augers, slide hammer samplers, shovels, stainless-steel spoons and bowls, soil sample liners and caps, wipe sampling templates, composite liquid waste samplers, and dippers. Equipment with a porous surface, such as rope, cloth hoses, and wooden blocks, cannot be thoroughly decontaminated and shall be properly disposed of after one use.

5.3 Frequency of Equipment Decontamination

Decontaminate down-hole drilling equipment and equipment used in monitoring well development and purging prior to initial use and between each borehole or well. Down-hole drilling equipment, however, may require more frequent cleaning to prevent cross-contamination between vertical zones within a single borehole. When drilling through a shallow contaminated zone and installing a surface casing to seal off the contaminated zone, decontaminate the drilling tools prior to drilling deeper. Initiate groundwater sampling by sampling groundwater from the monitoring well where the least contamination is suspected. Decontaminate groundwater, surface water, and soil sampling devices prior to initial use and between collection of each sample to prevent the possible introduction of contaminants into successive samples.

5.4 Cleaning Solutions and Techniques

Decontamination can be accomplished using a variety of techniques and fluids. The preferred method of decontaminating major equipment, such as drill bits, augers, drill string, and pump drop-pipe, is steam cleaning. To steam clean, use a portable, high-pressure steam cleaner equipped with a pressure hose and fittings. For this method, thoroughly steam wash equipment and rinse it with potable tap water to remove particulates and contaminants.

A rinse decontamination procedure is acceptable for equipment such as bailers, water level meters, new and re-used soil sample liners, and hand tools. The decontamination procedure shall consist of the following: (1) wash with a non-phosphate detergent (Alconox®, Liquinox®, or other suitable detergent) and potable water solution; (2) rinse with potable water; (3) spray with laboratory-grade isopropyl alcohol; (4) rinse with deionized or distilled water; and (5) spray with deionized or distilled water. If possible, disassemble equipment prior to cleaning. Add a second wash at the beginning of the process if equipment is very soiled.

Decontaminating submersible pumps requires additional effort because internal surfaces become contaminated during usage. Decontaminate these pumps by washing and rinsing the outside surfaces using the procedure described for small equipment or by steam cleaning. Decontaminate the internal surfaces by recirculating fluids through the pump while it is operating. This recirculation may be done using a relatively long (typically 4 feet) large-diameter pipe (4-inch or greater) equipped with a bottom cap. Fill the pipe with the decontamination fluids, place the pump within the capped pipe, and operate the pump while recirculating the fluids back into the pipe. The decontamination sequence shall include: (1) detergent and potable water; (2) potable water rinse; (3) potable water rinse; and (4) deionized water rinse. Change the decontamination fluids after each decontamination cycle.

Solvents other than isopropyl alcohol may be used, depending upon the contaminants involved. For example, if polychlorinated biphenyls or chlorinated pesticides are contaminants of concern, hexane may be used as the decontamination solvent; however, if samples are also to be analyzed for volatile organics, hexane shall not be used. In addition, some decontamination solvents have health effects that must be considered. Decontamination water shall consist of distilled or deionized water. Steam-distilled water shall not be used in the decontamination process as this type of water usually contains elevated

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concentrations of metals. Decontamination solvents to be used during field activities will be specified in the project WP.

Rinse equipment used for measuring field parameters, such as pH (indicates the hydrogen ion concentration – acidity or basicity), temperature, specific conductivity, and turbidity with deionized or distilled water after each measurement. Also wash new, unused soil sample liners and caps with a fresh detergent solution and rinse them with potable water followed by distilled or deionized water to remove any dirt or cutting oils that might be on them prior to use.

5.5 Containment of Residual Contaminants and Cleaning Solutions

A decontamination program for equipment exposed to potentially hazardous materials requires a provision for catchment and disposal of the contaminated material, cleaning solution, and wash water.

When contaminated material and cleaning fluids must be contained from heavy equipment, such as drill rigs and support vehicles, the area must be properly floored, preferably with a concrete pad that slopes toward a sump pit. If a concrete pad is impractical, planking can be used to construct solid flooring that is then covered by a nonporous surface and sloped toward a collection sump. If the decontamination area lacks a collection sump, use plastic sheeting and blocks or other objects to create a bermed area for collection of equipment decontamination water. Situate items, such as auger flights, which can be placed on metal stands or other similar equipment, on this equipment during decontamination to prevent contact with fluids generated by previous equipment decontamination. Store clean equipment in a separate location to prevent recontamination. Collect decontamination fluids contained within the bermed area and store them in secured containers as described below.

Use wash buckets or tubs to catch fluids from the decontamination of lighter-weight drilling equipment and hand-held sampling devices. Collect the decontamination fluids and store them on site in secured containers, such as U.S. Department of Transportation-approved drums, until their disposition is determined by laboratory analytical results.

6.0 Quality Control and Assurance

A decontamination program must incorporate quality control measures to determine the effectiveness of cleaning methods. Quality control measures typically include collection of equipment blank samples or wipe testing. Equipment blanks consist of analyte-free water that has been poured over or through the sample collection equipment after its final decontamination rinse. Wipe testing is performed by wiping a cloth over the surface of the equipment after cleaning. These quality control measures provide "after-the fact" information that may be useful in determining whether or not cleaning methods were effective in removing the contaminants of concern.

7.0 Records, Data Analysis, Calculations

Any project where sampling and analysis is performed shall be executed in accordance with an approved sampling and analysis plan. This procedure may be incorporated by reference or may be incorporated with modifications described in the plan.

Deviations from this procedure or the sampling and analysis plan shall be documented in field records. Significant changes shall be approved by the **Program Quality Control Manager**.

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8.0 Attachments or References

8.1 ASTM Standard D5088. 2008. *Standard Practice for Decontamination of Field Equipment Used at Waste Sites.* ASTM International, West Conshohocken, PA. 2008. DOI: 10.1520/D5088-02R08. www.astm.org.

8.2 NAVSEA T0300-AZ-PRO-010. *Navy Environmental Compliance Sampling and Field Testing Procedures Manual*. August 2009.

Author	*Reviewer*	*Revisions (Technical or Editorial)*
Phil Granger, Field Manager	Chris Barr, Program Quality Control Manager	Rev 0 – Initial Issue

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Monitoring/Injection Well Drilling, Installation and Abandonment

Procedure 3-12

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) describes the methods and procedures used during the drilling, installation and abandonment of groundwater injection and monitoring wells. It describes the components of well design and installation and sets forth the rationale for use of various well installation techniques in specific situations.

1.2 This procedure is the Program-approved professional guidance for work performed by AECOM-Envirocon Joint Venture (AEJV) for task orders issued under the Performance Based Environmental Multiple Award Contract Number N62473-11-D-2231.

1.3 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review.

2.0 Safety

Field personnel shall perform work in accordance with the site-specific health and safety plan (SSHSP). During well installation, subcontractors in direct contact with potentially contaminated media shall wear the proper personal protective equipment (PPE) as outlined in the SSHSP. Failure to comply will result in disciplinary action. In addition, all drill rigs shall ensure that a guard is in place around the auger (physical guard around the auger; barricade around the perimeter of the auger; or electronic brake activated by a presence-sensing device) to guard against employee contact with the auger.

If circumstances warrant, a real-time immediate response instrument, such as a Miniram Dust Monitor, organic vapor analyzer, HNu, Thermo, Draeger or Sensidyne tubes, or explosimeter, will be used to monitor the work area. When real/time instrument response exceeds the permissible exposure limit, **personnel** shall don the appropriate PPE and alternate control measures to ensure personnel safety. If safe control measures are not achievable, field activities shall be discontinued **immediately.**

Depending upon the type of contaminant expected, the following subsections describe safe work practices to be employed.

2.1 **General Procedures**

- Conduct subsurface utility clearance before any subsurface activities begins. Use the regional utility clearance hotline as well as a private utility locating service.
- Check for, and avoid any overhead utilities before setting drill rigs at any well locations.
- Avoid skin contact with and/or incidental ingestion of soil cuttings.
- Utilize protective clothing, steel-toed boots, gloves, hearing protection, and safety glasses as warranted.
- Stand upwind of the borehole, and/or use respiratory protection to avoid breathing constituents vented from the boring.
- Set up site control around the drill rig to keep unnecessary personnel from entering the drilling area.

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2.2 **Flammable or Explosive Conditions**

- If warranted, monitor explosive gases as continuously as possible using an explosimeter and oxygen meter.
- Place all ignition sources upwind or crosswind of the borehole.
- If explosive gases exceed the designated action levels as specified in the site-specific HSP, cease operations and evaluate conditions.

2.3 **Physical Hazards associated with Well Installation**

- To avoid lifting injuries associated with hollow-stem continuous-flight auger use and general well installation practices, use the large muscles of the legs, not the back. Use mechanical means of lifting whenever possible.
- Stay clear of all moving equipment and avoid wearing loose fitting clothing.
- When using cutting devices, cut away from self.
- To avoid slip/trip/fall conditions as a result of drilling activities, keep the area clear of excess soil cuttings and use textured boots/boot cover bottoms in muddy areas. Practice good housekeeping procedures in and around all work and staging areas.
- To avoid heat/cold stress as a result of exposure to extreme temperatures and PPE, drink electrolyte replacement fluids (1 to 2 cups per hour is recommended) and, in cases of extreme cold, wear fitted insulating clothing.
- Be aware of restricted mobility caused by PPE.

3.0 Terms and Definitions

3.1 **Filter Pack:** Filter pack is sand or gravel that is smooth, uniform, clean, well-rounded, and siliceous. It is placed in the annulus of the well between the borehole wall and the well screen to prevent formation materials from entering the well and to stabilize the adjacent formation.

3.2 **Annulus:** The annulus is the down hole space between the borehole wall and the well casing and screen.

3.3 **Bridge:** A bridge is an obstruction in the drill hole or annulus. A bridge is usually formed by caving of the wall of the well bore, by the intrusion of a large boulder, or by filter pack materials during well completion. Bridging can also occur in the formation during well development.

3.4 **Grout:** Grout is a fluid mixture of cement and water that can be forced through a pipe and emplaced in the annular space between the borehole and casing to form an impermeable seal. Various additives, such as sand, bentonite, and polymers, may be included in the mixture to meet certain requirements.

3.5 **Sieve Analysis:** Sieve analysis is the evaluation of the particle-size distribution of a soil, sediment, or rock by measuring the percentage of the particles that will pass through standard sieves of various sizes.

4.0 Training and Qualifications

4.1 **Project Managers (PMs)** are responsible for issuing work plans (WPs) that reflect the procedures and specifications presented in this procedure. Individual municipalities, county agencies, and possibly state regulatory agencies enforce regulations that may include well construction and installation requirements. The **PM** shall be familiar with current local and state regulations, and ensure that these regulations are followed. Regulations are subject to constant revision. Every effort should be made to stay informed of these changes through contact with the agencies that oversee work in specific project areas, prior to initiation of field activities. The **PM** or **designee** shall review all well construction logs on a minimum

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monthly basis. The **PM** is responsible for ensuring that all personnel involved in monitoring well installation and abandonment shall have the appropriate education, experience, and training to perform their assigned tasks.

4.2 The **Program Quality Control Manager** is responsible for ensuring overall compliance with this procedure.

4.3 The **Field Manager** is responsible for direct supervision of the installation of monitoring wells and ensuring that procedures and specifications in the field are properly and safely implemented. The qualifications for the **Field Manager** include a degree in geology, hydrogeology, environmental science, or civil/geotechnical/environmental engineering with at least 2 years of field experience in the installation of monitoring wells. The Field Manager must have completed the 30-hour OSHA construction training.

4.4 All **field personnel** are responsible for the proper and safe implementation of this procedure. **Field personnel** must have completed the 40-hour HAZWOPER training and be up to date on annual refresher courses. **Field personnel** must be currently enrolled in a medical monitoring program.

4.5 The **Field Manager** or **designee** is expected to obtain a description of the lithologic samples obtained during the borehole drilling and construction of each well. These data are often required to provide guidance regarding the installation of specific components of the well.

5.0 Equipment and Supplies

5.1 CME 85 or CMW 95 Hollow Stem Auger drill rig: Truck or track mounted drill rig capable of advancing hollow stem augers to desired depths. Fitted with a manual or auto-hammer to collect undisturbed split-spoon samples ahead of the drill bit.

5.2 Direct Push drill rig: Truck or track mounted direct push drill rig capable of advancing 2.25-inch drill rods to the desired depth.

5.3 Emulsified Vegetable Oil or similar subsurface biological amendment:

6.0 Calibration or Standardization

7.0 Procedure

7.1 Well Design Considerations

The following information is compiled from a number of technical references. For additional information related to well installation, consult the references listed in the last section of this procedure.

7.1.1 Well Placement

The location of monitoring and injection wells should be determined during the development of the work plan. Changes in well locations may have to be made in the field based upon underground and overhead utility locations, topographic features and site access issues. Any changes to well locations should be discussed with the project team.

7.1.2 Well Depth and Screened Interval

Well Depths and screened intervals for monitoring and injection wells should be determined during the development of the work plan. Based upon subsurface conditions encourtered during drilling, the well depths and screen intervals may need to be adjusted and should be discussed with the project team before permanent decisions are made.

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7.1.3 Well Permitting

All wells shall be permitted in accordance with the regulations of the local jurisdiction where well installation is occurring. Contact local authorities prior to establishing well construction requirements for the project.

The permit procedure may require permit fees, site inspections, and an application signed by a **registered professional geologist** or **engineer**. Permit requirements may affect field schedules and budgets. The **driller** may also be required by law to be licensed and bonded. Provide documentation that all legal requirements have been met to the appropriate agencies prior to the drilling and installation of monitoring and injection well.

7.2 Selection of Drilling Method

There are a number of different drilling methods that may be employed for the installation of monitoring and injection wells. Drilling methods should be established during the development of the work plan based upon the depth and location of the well, subsurface conditions and regulatory requirements. Conditions encountered during drilling may limit the depth of borehole advancement, and a change in the drilling method may be needed. Any changes in the drilling method should be discussed with the project team. Technical, budgetary and regulatory requirements should be considered before any changes are made.

The following subsections discuss commonly used drilling methods and their applicability to installation of monitoring wells. Regardless of the drilling method selected, decontaminate all drilling equipment using Procedure 3-06, *Equipment Decontamination*. Follow these procedures before use and between borehole locations to prevent cross-contamination. In addition to selecting the proper drilling technique, take other precautions to prevent distribution of any existing contaminants throughout the borehole or across different water bearing units.

7.2.1 Hollow-Stem Continuous-Flight Auger

HSA is the most frequently employed method used in the environmental industry for the drilling and installation of shallow wells in unconsolidated materials. Drilling with HSA is possible in loose sand and gravel, loose boulders in alluvium, clay, silt, shale, and sandstone. HSA drilling is usually limited to unconsolidated materials and depths of approximately 150 to 200 feet. HSA drill rigs are mobile, relatively inexpensive to operate, generally cause minimal disturbance to the subsurface materials, and have the additional advantage of not introducing drilling fluids (e.g., air, mud, or foam) to the formation.

Another advantage of the HSA method is that undisturbed samples are obtained by driving a split-spoon sampler below the lead drill bit. Soil samples can usually be easily collected in this manner with a minimum of tripping sampling tools into and out of the hole.

Moreover, in the HSA drilling method, the well is constructed inside the HSAs as the augers are gradually removed from the ground. This method decreases the possibility of the borehole collapsing before the well is installed. HSAs shall have a nominal outside auger-flight diameter of 10 to 12 inches and a minimum inside diameter of 8 inches. Larger inside diameter auger flights are sometimes available. Well casing diameter is usually limited to 4 inches or less when using the HSA method. The difference between the inner diameter (I.D.) of the auger and the outer diameter (O.D.) of the well casing shall be at least 4 inches (i.e., a minimum 2-inch annular space) to permit effective placement of filter pack, bentonite seal, and grout without bridging.

7.2.2 Direct Push

Direct push methods for monitoring and injection well installation are limited to use in unconsolidated formations such as alluvial/stream sediments, glacial deposits, and loose sediments. Direct push methods are generally successful at penetrating clays, silts, sands and some gravel to depths ranging from 50 to 75 feet bgs. Direct push methods are not designed for penetration of consolidated bedrocks.

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Direct push drilling involves driving steel rods through the subsurface using a truck mounted vibratory percussion hammer. The rods are typically hollow and can be driven using a solid fixed tip to push soil aside producing no soil cuttings, or using a retractable tip that allows continuous soil cores to be collected during drilling to depth, removing all soil from the borehole.

The direct push rods usually must be removed before well installation, which could cause borehole collapse in looser formations. Direct push technology is typically the fastest and least expensive method of drilling, but well sizes are limited to 2-inch OD or less, and there are depth limitations.

For the purposes of substrate injection the direct push rig can advance drill rods to the desired depth, pull back on the drill rod string to expose the sampling/injection screen, and inject substrate into the subsurface through the drill rods, under pressure. This procedure allows a one-time injection without the costs associated with a permanent well construction and subsequent abandonment.

7.3 Monitoring Well Design Procedures

Discussion of the design of the individual components of a typical monitoring well is given in the following subsections.

7.3.1 Pre-Installation Design Drawing

Develop a pre-installation design drawing before the borehole for the well is drilled, and borehole-specific lithologic and hydrologic information are available. The pre-installation design should be based on previous borings and other site specific data that is available. The pre-design drawing shall identify the anticipated depth of the well, the locations of the top and bottom of the screened interval, the anticipated top of the filter pack, the anticipated top of the bentonite seal, and the locations of centralizers (if applicable). In addition, calculate the volumes of sand, bentonite, and grout anticipated to be placed in the annular space of the well. Maintain the drawing as documentation of the well design. Based upon the subsurface conditions during drilling the well design may need to be modified at the time of installation. Any changes to the well design should be discussed with the project team and regulators before well installation proceeds.

7.4 Monitoring/Injection Well Installation Techniques

The following general procedures describe the installation of injection or groundwater monitoring wells.

7.4.1 General Casing and Screen Installation Techniques

Following completion of the borehole, the **Field Manager** or **designee** will first measure the total depth of the borehole to ensure that the desired depth has been attained. The lengths of casing and screen shall also be measured. These measurements shall be made with an accuracy of 0.01 feet using either a fiberglass or steel tape measure.

Installation of the casing and screen is normally accomplished by emplacing them into the borehole as an integral unit. Prior to installation, decontaminate individual lengths of the well casing and screen according to Procedure 3-06, *Equipment Decontamination*, unless the casing and screen were certified by the manufacturer to have been properly pre-cleaned at the factory and sealed in plastic. Following decontamination, inspect each length to ensure that damaged or otherwise unsuitable sections are not used.

To ensure even distribution of filter pack, bentonite seal, and grout materials around the well within the borehole, suspend the casing and screen with a threaded hoisting plug and do not allow them to rest on the bottom of the boring unless the installation is less than 30 feet deep.

A clamp may be used to hold the well string at the surface so the hoisting plug can be removed as additional screen or casing pieces are added during installation. The length of the clamp must be wider than the borehole diameter and have a solid, stable platform to rest upon during construction of the well.

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7.4.2 Centralizers

Install centralizers at the top and bottom of screened sections when using the air or mud rotary techniques for well installation. Also place centralizers at 20- to 40-foot intervals on blank casing; the **Field Manager** will determine the spacing according to the depth of the well. Align the centralizers from top to bottom of the casing so that they do not interfere with the insertion and removal of the tremie pipe and measuring tape. All devices used to affix centralizers to the casing shall not puncture the casing or contaminate the groundwater with which they come in contact. Centralizers shall be constructed of stainless steel.

7.4.3 Filter Pack Installation

Prior to the addition of any filter pack material, cover the top of the well casing to prevent filter pack material from entering it.

The filter pack is usually installed through HSAs, conductor casing, or a tremie pipe depending on the drilling technique used; however, if the depth to the bottom of the screened interval is less than 10 feet and lithologic materials are sufficiently consolidated to preclude the possibility of hole collapse, the filter pack may be poured into the annular space of the well from the ground surface. This procedure applies to any drilling method.

During installation, measure the level of the top of the filter pack periodically to ensure that no bridging has occurred, and to determine the depth to the top of the filter pack. Be sure that the filter pack encloses the entire length of the screened section. For wells less than 100 feet in total depth, the filter pack shall generally extend to 2 feet above the top of the screened section of the well. For wells greater than 100 feet in total depth, an additional 1 foot of filter pack may be emplaced above the screen for each 100 feet of well depth.

Following the installation of the filter pack, a surge block or large bailer shall be moved up and down the length of the screen interval for approximately 10 minutes to set and compact the filter pack and to begin well development. After surging the well, check the level of the filter pack again. Add more filter pack material according to the procedures described above if any settling of the filter pack has occurred, and repeat the surging process to set the additional filter pack. After emplacement, note the volume of filter pack material placed in the well, record it in the well completion record (Figure 3-12-1), and compare it to the calculated volume of filter pack that was expected to have been used. Record the depth to the top of the filter pack from the ground surface.

7.4.4 Annular Seal Installation

The sodium bentonite transition seal shall have a minimum thickness of 3 feet. It may be constructed of powdered, granular, or pelletized bentonite, and may be emplaced as a dry solid, powder, or slurry. Use only sodium bentonite manufactured specifically for use in the drilling and construction of water wells. Typically, granular or pelletized bentonite is emplaced dry. Powdered bentonite is usually mixed with potable water to produce slurry. Depending on the type of installation method, the bentonite may be emplaced through the HSAs, conductor casing, or tremie pipe.

In dry form, place the bentonite directly on the top of the filter pack. After emplacing each 1-foot-thick layer of dry bentonite in the well, add approximately 5 gallons of water of known chemical quality to hydrate the bentonite. Allow a minimum of 15 minutes for hydration of the bentonite seal once it has been completely installed.

When emplacing the bentonite in slurry form, take care that the bentonite is thoroughly mixed, with no visible lumps, to ensure the proper consistency. Before placement of the seal, place a 1-foot layer of fine-grained silica sand over the top of the filter pack. This fine-grained sand layer will prevent invasion of the filter pack by the bentonite slurry.

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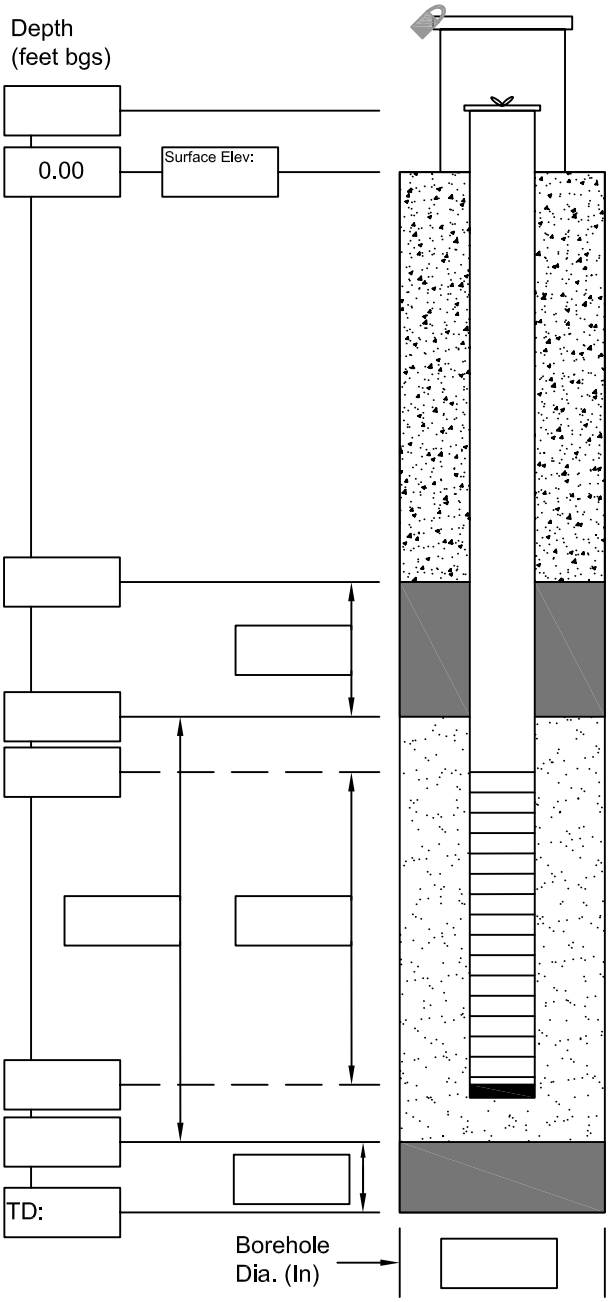
Monitoring/Injection Well Construction Log

Project Name:	Project Number:	
Project address:	Well ID:	Sheet_____of_____
Drillers name:	Borehole Diameter (in):	Total Depth (ft bgs):
Drilling Company:	Date Started:	Approx. Depth to Water (ft bgs):
Drilling Equipment:	Date Completed:	TOC Elevation and Datum:
Drilling Method:	Logged by:	Northing and Datum:
Drilling Fluid:	Checked by:	Easting and Datum:



Protective Casing
Material/Type: _____
Diameter: _____

Guard Posts (Y/N)

Surface Pad
Type: _____

Well Casing
Type: _____
Diameter: _____
Interval BGS: _____

Well Casing Screen
Type: _____
Diameter: _____
Slot Size and Type: _____
Interval BGS: _____

Sanitary Seal/Cement
Type: _____
Interval BGS: _____
Quantity: _____
Tremied (Y/N)

Centralizers
Depth: _____

Bentonite Seal
Type: _____
Setup/Hydration time: _____
Interval BGS: _____
Quantity: _____
Tremied (Y/N)

Filter Pack
Type: _____
Interval BGS: _____
Quantity: _____
Tremied (Y/N)

Bottom Cap
Type: _____
Interval BGS: _____

Bottom Bentonite Seal
Type: _____
Setup/Hydration time: _____
Interval BGS: _____
Quantity: _____
Tremied (Y/N)

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Following the emplacement of the transition bentonite seal, emplace the remaining annular seal. The annular seal shall be slurry consisting of 7 to 9 gallons of water per 94-pound bag of Portland cement Type I or II and a minimum of 3 to 5 percent bentonite (1/4 to 1/2 bags of bentonite powder per five bags of Portland cement). The slurry may be emplaced through an HSA, conductor casing, or tremie pipe, depending on the method of installation. Thoroughly mix the grout to ensure the proper consistency with no visible lumps of dehydrated powder. The rates at which the augers or pipe are withdrawn and the slurry added will be such that the level of the grout within the well annulus is just below the lowermost auger or pipe.

If a tremie pipe is used, emplace the annular grout seal by pumping through a pipe with a minimum 1-inch I.D., in one continuous pour, from the top of the transition seal to the ground surface. Place the bottom of the tremie pipe about 5 to 10 feet above the transition seal, depending on the stability of the hole and impact velocity of the grout.

A tremie pipe is not required for annular seals less than 10 feet from the ground surface to the top of the transition seal or for grouting within dual wall drill strings or HSAs. Measure the volume of grout seal material placed in the well, record it in the well construction log, and compare it with the calculated volume. The slurry shall extend from the top of the bentonite seal to a depth of approximately 2 feet below ground surface (bgs).

7.4.5 Annular Seal "Set Time" and Setting

Let the annular grout seal set at least 12 hours before disturbing the casing or well so that separations or breaks do not occur between the seal and the casing, or between the seal and the borehole. Development of the well is prohibited until the grout seal has set. Likewise, the concrete slab, traffic box, and/or casing riser of the surface completion shall not be poured and constructed until the grout seal has set. Top off any settlement of the grout seal as soon as possible after it sets. Record all pertinent data on the well construction log.

7.4.6 Surface Completion

The surface of a groundwater monitoring well shall be either an aboveground completion or as a flush-to-ground completion. Regardless of the method, each monitoring well shall have, at a minimum, a casing cap, concrete slab and annular seal, and a locking protective casing or locking vault.

In an aboveground completion, the protective casing or monument is installed around the top of the well casing within a cement surface seal. A 2-foot-long by 2-foot-wide cement pad with a minimum thickness of 3 inches is constructed around the protective casing. Type 1 Portland cement, which meets the requirements of Class A standards, is used for the surface seal. Inspect the monument prior to installation to ensure that no oils, coatings, or chemicals are present. Once installed, maintain the monument in a plumb position with 2 to 3 inches of clearance between the top of the well casing and the lid of the monument. The monument shall extend at least 18 inches above grade and at least 12 inches below grade. In areas where frost heaving is considered a factor, the casing shall extend below the frost depth. Construct a minimum of three concrete-filled posts around the well to protect it from vehicular damage.

Inside the monument, cut or scribe two permanent survey marks, approximately 0.25 inches apart, into the top of the well casing and permanently mark the well with its identification number. Cover the top of the well casing with a slip cap or locking cap to prevent debris from entering the well. Fit the monument with a casehardened lock to prevent unauthorized entry.

In a flush-to-ground completion, the protective casing or traffic box is installed around the top of the well casing, which has been cut off slightly below grade. The traffic box has a lid that is held firmly in place by bolts and has a flexible O-ring or rubber gasket to prevent water from entering the box. The traffic box is set within a cement surface seal slightly above grade to deflect surface water flow away from the well. The surface seal extends to a minimum of 4 inches from the outer rim of the traffic box. Type 1 Portland cement, which meets the requirements of Class A standard, is used for the surface seal. Inspect the

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traffic box prior to installation to ensure that no oils, coatings, or chemicals are present. Once installed, maintain the traffic box in a level position that leaves 2 to 3 inches of clearance between the top of the well casing and the lid of the traffic box.

Cut two permanent survey marks into the top of the well casing approximately 0.25 inches apart and permanently mark the well with its identification number. Cover the top of the well casing with a lockable cap to prevent debris from entering the well. Also, fit the lockable cap with a casehardened lock to prevent unauthorized entry.

7.4.7 Installation of Surface Casing

The use of surface casing may be required to minimize the potential for cross-contamination of different hydrogeologic zones within the subsurface of a site. The depth of placement of the surface casing shall be based on site-specific geologic knowledge obtained from lithologic samples collected in situ during the drilling of the well boring.

If a surface casing is to be installed permanently along with the well, grout it in place. The borehole shall be of sufficient diameter that a tremie or grout pipe can be easily placed between the borehole wall and the outside of the surface casing. After the desired placement depth is reached and the drilling tools are removed from the borehole, lower the casing into the borehole and center it. The bottom of the surface casing may be plugged or driven into the sediment at the base of the borehole to keep grout from entering the casing, if necessary.

Install grout through the tremie pipe and pump it from the bottom of the casing to ground surface. As the grout is being placed, raise the tremie pipe slowly to avoid excessive backpressure and potential clogging of the tremie pipe. After the grout has been allowed to set for at least 24 hours, drilling and subsequent well installation can continue. The required time for grout to set before drilling can continue depends on the volume of grout emplaced; the more grout used, the longer the delay time.

7.4.8 Well Construction Recordkeeping Procedures

A written well completion record (Figure 3-12-1) detailing the depths, timing, amount of materials, and methods of installation/construction for each step of monitoring well construction shall be prepared during construction of each monitoring well by the **Field Manager** or **designee**. Construction records shall be kept in a hardbound field notebook dedicated to the CTO. An “as-built” drawing illustrating the placement location and amounts of all materials used in construction of each monitoring well shall be prepared in the field at the time of construction. The well construction record shall be filled out with indelible ink. Construction records shall include the date/time and quantities of materials used at each of the following stages of monitoring well construction, including:

- Drilling
  - Drill rig type
  - Drilling method/coring method
  - Drill bit/core barrel diameter (hole diameter)
  - Drill company, driller, helper(s)
  - Field geologist, supervising geologist
  - Dates/times start and finish drilling hole, interval drilling rates
  - Total depth of hole
  - Drilling location, surveyed ground elevation
  - Inclination of hole from horizontal
- Borehole abandonment – type, volume, and surface seal

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- Casing material
  - Type
  - Top and bottom of section as actually installed
  - Length
  - Depth Interval
- Casing decontamination – document process and equipment used
- Casing diameter – nominal I.D. of casing
- Screen material
  - Type
  - Top and bottom of section as actually installed
  - Length
  - Depth Interval
  - Slot type, size, shape
  - Type of bottom plug and/or cap used
- Filter pack material
  - Composition and size gradation
  - Manufacturer
  - Actual volume and depth of top and bottom of filter pack
  - Calculated volume versus actual volume used and explanation of discrepancies
- Transition seal
  - Composition and depth of top and bottom of seal
  - Size (or gradation) or material used (e.g., pellets, granulated, or powdered)
  - Time allowed for hydration prior to emplacement of annular grout slurry seal
- Annular slurry seal
  - Date and time of beginning and completion of annular seal
  - Type, depth interval, and actual volume of seal
  - Calculated volume versus actual volume and explanation of discrepancies
  - Set time allowed prior to commencement of additional work
- Surface completion
  - Type of construction
  - Nature of materials used for surface completion
  - Date/time of completion

7.4.9 Well Location

A **registered land surveyor** shall survey each monitoring well location for exact horizontal location to the nearest 0.5 foot, and exact vertical location to the nearest 0.01 foot, referenced to mean sea level or mean low low water. The vertical elevation shall be surveyed between the two notches cut in the top of

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the well casing, which is the point from which all water level measurements shall be made. The elevation of the ground or top of the concrete slab adjacent to the monitoring well shall also be surveyed, to the nearest 0.01 foot.

7.5 Well Abandonment/Destruction

Once a monitoring well is no longer needed as part of an investigation, or has been damaged to the extent that it cannot be repaired, it is essential that it be properly abandoned. The proper abandonment of a monitoring well ensures that the underlying groundwater supply is protected and preserved. In addition, proper well abandonment eliminates a potential physical hazard and liability. An additional permit and/or inspection may be required for abandonment.

The standard procedures for the abandonment of a groundwater monitoring well apply to the HSA drilling method. This type of installation was chosen because it is the primary method of abandoning groundwater monitoring wells.

The first step in abandoning a groundwater monitoring well is to remove the surface completion from around the top of the well casing. This is normally accomplished using a jackhammer to break the surface cement seal, and then removing the monument or traffic box. When the surface seal and the wellhead cover have been removed, over-drill the well to its total depth using HSAs. Once the total depth of the well has been reached, remove the casing and screen from the borehole. Then completely backfill the borehole with a grout seal. Typically, the grout seal is emplaced as slurry of Portland cement grout, which contains a minimum of 3 to 5 percent bentonite as described in Section 7.4.5 When mixing the slurry, take care that the bentonite is mixed according to the manufacturer's specifications to ensure the proper consistency.

Emplace the slurry through the HSAs. The rates at which the augers are withdrawn and the slurry is added shall be such that the level of the slurry within the borehole is just below the lead auger. The borehole seal shall extend from the total depth of the borehole to a depth of approximately 1 foot bgs. Then repair the surface to prior conditions and grade.

If the monitoring well casing cannot be pulled or drilled out, perforate the well casing adjacent to the saturated zones so that the annular space and any nearby voids can be filled with sealing material. Fill the perforated well or borehole from the bottom up with an appropriate sealing material, such as neat cement. Inject the neat cement under pressure to force it into the annular space, nearby voids, and filter pack. Apply pressure for a sufficient time to allow the cementing mixture to set. After the cement has hardened, excavate a hole around the well with a backhoe to the depth specified in the Monitoring Well Abandonment Work Plan and ensure the excavation depth is in accordance with local regulatory agency guidelines. Remove the uppermost portion of the casing, (if still in place), and pour a cement cap on top of the abandoned well, and backfill the remaining portion of the excavation with sealing material. Note, if **personnel** are required to enter the excavation to remove the upper portion of the casing, then proper sloping and shoring are required as per Section 25, *Excavation and Trenching*, of Safety – Safety and Health Requirements, EM 385-1-1 (USACE 2008).

7.6 Vapor Extraction/Monitoring Wells

Vapor extraction/monitoring wells have most of the same design and installation considerations and procedures as groundwater monitoring wells, with the exception that they are screened in the unsaturated zone. Vapor extraction/monitoring wells generally shall not be screened over an interval greater than 20 feet and shall not be screened over two or more lithologies that have air permeabilities that differ by more than one order of magnitude. Vapor extraction/monitoring wells shall be installed using drilling techniques that do not require drilling fluids other than filtered air. Vapor monitoring wells may have casing I.D.s of 2 inches or less while extraction wells shall generally have casing I.D.s of at least 4 inches. The design of vapor extraction/monitoring wells is dependent upon many site-specific factors, such as the depth of contamination, soil conditions, geology, and depth to groundwater. As a

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result, specifics related to the design of these wells shall be included in the project WP, sampling and analysis plan, or plans and specifications.

7.7 Drive Points

An alternative to conventional monitoring well construction is, under limited conditions, the use of drive points. These consist of slotted steel pipe that is pushed, hammered, or hydraulically jetted into the ground. A filter pack is not constructed around the screen, so the width of the screen openings must be sufficiently small to prevent the passage of significant quantities of sediment into the well during the withdrawal of water for sampling. In some instances, the drive points are used only as piezometers.

Drive points are commonly used in hazardous waste investigations to sample ambient soil gases in the vadose zone. It is often possible to extend the drive point below the water table to collect water samples. Drive points may also be used as temporary injection wells for subsurface substrate injections. In some instances, permits may be required because the drive points are considered in some jurisdictions to be equivalent to a temporary monitoring well.

7.8 Hydropunch Sampling

Another alternative to conventional monitoring well construction is the use of a discrete groundwater sampling device known as a Hydropunch. The Hydropunch tool can be used in conjunction with a standard drill rig, a cone penetrometer rig, or possibly a vehicle capable of driving vapor probes to sample groundwater and non-aqueous phase liquid in unconsolidated formations. The Hydropunch tool is constructed of a stainless steel drive point, a perforated section of Teflon pipe for a sample intake, and a stainless steel sample chamber. The tool is 55.5 inches long, 2 inches in O.D., and weighs approximately 24 pounds.

Ideally, a standard HSA drill rig is used to drill a pilot hole to a depth just above the desired sampling depth. The Hydropunch tool is then hydraulically pushed or driven 4 to 5 feet through the saturated zone at each sampling location. As the tool is advanced, the sample intake screen remains pristine within the watertight stainless steel chamber. When the desired sampling interval is reached, the steel sampling chamber is unscrewed and withdrawn 1 foot to several feet, depending on how discrete a sampling interval is needed. This exposes the intake screen to the groundwater. Under hydrostatic pressure, groundwater flows through the intake screen and fills the sample chamber, without aeration or agitation occurring. The drive cone, which is attached to the base of the screen, will remain in place by soil friction.

The pointed shape of the sampler and its smooth exterior surface prevent downward transport of surrounding soil and groundwater as the tool is advanced. Once in place, the intake screen will be sealed from groundwater above and below the interval being sampled, because the exterior of the Hydropunch tool is flush against the surrounding soil wall. Additionally, as the tool is advanced, the sample intake screen is retained within the steel watertight sample chamber.

A stainless steel or Teflon bailer with a bottom check valve is lowered into the sample chamber to collect the groundwater sample. Groundwater is then decanted at ground surface from the bailer into the appropriate sample containers.

7.9 Pre-Pack Well Installation

An alternative to conventional monitoring well construction and installation is through the use of small diameter pre-fabricated monitoring wells, commonly referred to as “pre-pack” wells. Pre-pack wells typically consist of a well screen (slotted PVC) surrounded by sand (filter-pack) held in place by a stainless steel or polyethylene mesh. The pre-pack well assembly is commonly used in conjunction with direct-push drilling methodologies, which allows a relatively quick installation of these small diameter wells

Having the filter pack around the slotted PVC before the well screen is installed ensures that the filter pack is located directly around the well screen and minimizes the effort required for the filter pack installation.

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During installation, the boring is advanced using hollow drive rods with an expendable drive point. Upon reaching the desired monitoring well installation depth, the entire well assembly (i.e., pre-pack well) is lowered to the desired depth within the hollow drive rods. At the desired depth, the hollow drive rods are retracted to a point above the screen. At this step, a barrier is placed directly above the screen to prevent grout or material from entering the screened interval as the hollow drive rods are extracted from the boring. This barrier can be created either by natural formation collapse (occurring during the initial rod retraction), by gravity installation of fine-grade sand through the rod annulus, or as part of the pre-pack monitoring well components (e.g., expanding foam bridge). With the barrier in place, granular bentonite or bentonite slurry is then installed in the annulus to form a well seal.

Vendors offer pre-pack monitoring well components with varying outer diameters, which is typically based on the inner diameter of the hollow drill rods.

These types of wells may be sampled by several methods, including peristaltic pump, mini-bailer, or bladder pump, to yield data of similar quality to that of conventional monitoring wells.

8.0 Quality Control and Assurance

Well installation and abandonment activities must incorporate quality control measures to ensure that proper procedures have been followed. All well material must be inspected for cleanliness and to ensure it is undamaged before being placed in the borehole. Measurements should be taken multiple times and checked by the driller, field geologist, and QC manager to ensure the well is constructed to proper specifications.

Quality control measures typically include :

- Inspection of all well material before emplacement in the borehole
- Take multiple measurements of screen and well casing to ensure proper length, and that the well is constructed to the exact specifications of the design.
- As filter pack, bentonite and grout seal materials are emplaced in the borehole, measurements should continually be taken to ensure that the proper depth intervals are achieved. It is much easier to place more material in the borehole than to remove material after it has been emplaced.
- Compare quantity of materials used, to the quantities estimated for the initial design. Try to rectify any substantial differences to ensure proper well construction and installation.

These quality control measures provide a level of insurance that the monitoring/injection well has been properly installed and will perform and function the way it has been designed.

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9.0 Records, Data Analysis, Calculations

Monitoring well location, design, and construction shall be recorded in the field notebook for the CTO and on a well completion record form (Figure 3-12-1). The **Field Manager** should provide a copy of this form to the **PM** for the project files.

Deviations from this procedure shall be documented in field records. Significant changes shall be approved by the **Program Quality Control Manager**.

10.0 Attachments or References

10.1 Driscoll, F.G., Ph.D. 1986. *Ground Water and Wells*. St. Paul, MN: Johnson Division.

10.2 Environmental Protection Agency, United States (EPA). 1987. *A Compendium of Superfund Field Operations Methods*. Office of Solid Waste and Emergency Response. EPA/540/P-87/001.

10.3 EPA. 1990. *Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells*. EPA/600/4-89/034. Office of Research and Development, Washington. March.

10.4 EPA. 1992. *RCRA Groundwater Monitoring Draft Technical Guidance*. EPA/530/R-93/001. Office of Solid Waste. November.

10.5 Procedure 3-06, *Equipment Decontamination*.

10.6 U.S. Army Corps of Engineers. 2008. Manual No. EM 385-1-1. *Safety and Health Requirements*. 15 November 2008. http://140.194.76.129/publications/eng-manuals/em385-1-1/2008_English/toc.html.

Author	*Reviewer*	*Revisions (Technical or Editorial)*
Phil Granger, Field Manager	Chris Barr, Program Quality Control Manager	Rev 0 – Initial Issue – March 25, 2012

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Amendment Injection Procedures

Procedure 3-13

1.0 Purpose and Scope

1.1 This Standard Operating Procedure (SOP) describes the general procedural steps pertaining to the subsurface injection of bioremediation substrate.

1.2 This procedure is the Program-approved professional guidance for work performed by AECOM-Envirocon Joint Venture (AEJV) for task orders issued under the Performance Based Environmental Multiple Award Contract Number N62473-11-D-2231.

1.3 Substrate is amended to the subsurface by introducing a volume of water containing the desired concentration to a well or set of wells installed for this purpose. Injection volumes are designed to achieve a target radius of injection (ROI) around each injection well. Well spacings are selected to achieve reasonable coverage based on well ROI and groundwater flow conditions, creating a continuous passive biobarrier/bioreactive zone. The biobarrier is typically oriented perpendicular to the average horizontal groundwater flow direction to intercept the contaminant plume. Since the objective is to inject a target design volume of amendment, the injection duration will be governed by the rate at which the formation will accept flow.

1.4 Emulsified Vegetable Oil (EVO) and/or corn syrup will be introduced into each injection well. The injection will be controlled by the rate at which the subsurface is able to absorb the injected amendment and the total volume of amendment to be injected.

2.0 Safety

Field personnel shall perform work in accordance with the site-specific health and safety plan (SSHSP). During substrate injection, subcontractors in direct contact with potentially contaminated media shall wear the proper personal protective equipment (PPE) as outlined in the SSHSP. Failure to comply will result in disciplinary action.

If circumstances warrant, a real-time immediate response instrument, such as a Miniram Dust Monitor, organic vapor analyzer, HNu, Thermo, Draeger or Sensidyne tubes, or explosimeter, should be used to monitor the work area. When real/time instrument response exceeds the permissible exposure limit, **personnel** shall don the appropriate PPE and alternate control measures to ensure personnel safety. If safe control measures are not achievable, field activities shall be discontinued **immediately.**

Depending upon the type of contaminant expected, the following subsections describe safe work practices that will be employed.

2.1 **Particulate or Metal Compounds**

- Avoid skin contact with and/or incidental ingestion of soil cuttings.
- Utilize protective clothing, steel-toed boots, gloves, hearing protection, and safety glasses as warranted.
- Stand upwind of the boring, and/or use respiratory protection to avoid breathing constituents vented from the boring.

2.2 **Flammable or Explosive Conditions**

- If flammable or explosive conditions are anticipated, monitor explosive gases as continuously as possible using an explosimeter and oxygen meter.

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- Place all ignition sources upwind or crosswind of the borehole.
- If explosive gases exceed the designated action levels as specified in the SSHSP, cease operations and evaluate conditions.

2.3 **Physical Hazards associated with Amendment injection**

- Substrate injections usually occur under pressure through hoses. Fittings must be double-checked to ensure they are properly closed and secured to avoid coming becoming disconnected during injection.
- Stay clear of all moving equipment and avoid wearing loose fitting clothing.
- When using pocketknives for cutting purposes, cut away from self.
- To avoid slip/trip/fall conditions, as a result of injection activities, keep the work area clear of excess equipment, and practice good housekeeping procedures to keep working areas unobstructed.
- To avoid heat/cold stress as a result of exposure to extreme temperatures and PPE, drink electrolyte replacement fluids (1 to 2 cups per hour is recommended) and, in cases of extreme cold, wear fitted insulating clothing.
- To avoid hazards associated with subsurface utilities, ensure all sampling locations have been properly surveyed for utilities.
- Be aware of restricted mobility caused by PPE.

3.0 Terms and Definitions

3.1 **High Fructose Corn :** A substrate amendment injected into the subsurface to enhance the breakdown of perchlorate into its daughter products.

3.2 **Emulsified Vegetable Oil (EVO):** A substrate amendment injected into the subsurface to enhance the breakdown of perchlorate into its daughter products.

3.3 **Injection Well:** A permanent well screened in the target treatment zone, or a temporary well or drive point injection well used to introduce amendments to the subsurface.

3.4 **Injection Manifold:** Splits the injection substrate from the main line source to multiple lines for injection to multiple wells at the same time. Each individual line split from the main has separate ball valves, flow meters and pressure gauges to control distribution to each injection well.

4.0 Training and Qualifications

4.1 **Project Managers (PMs)** are responsible for issuing work plans (WPs) that reflect the procedures and specifications presented in this procedure. Individual municipalities, county agencies, and possibly state regulatory agencies enforce regulations that may include well construction and installation requirements. The **PM** shall be familiar with current local and state regulations, and ensure that these regulations are followed. Regulations are subject to constant revision. Every effort should be made to stay informed of these changes through contact with the agencies that oversee work in specific project areas, prior to initiation of field activities. The **PM** or **designee** shall review all well construction logs on a minimum monthly basis. The **PM** is responsible for ensuring that all personnel involved in monitoring well installation and abandonment shall have the appropriate education, experience, and training to perform their assigned tasks.

4.2 The **Program Quality Control Manager** is responsible for ensuring overall compliance with this procedure.

4.3 The **Field Manager** is responsible for direct supervision of the injection activities and ensuring that procedures and specifications are implemented in the field. The qualifications for the **Field Manager**

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include a degree in geology, hydrogeology, environmental science, or civil/geotechnical/environmental engineering with at least 2 years of field experience in the installation of monitoring wells.

4.4 All **field personnel** are responsible for the implementation of this procedure.

4.5 The **on-site staff** is expected to obtain a description of the lithologic samples obtained during the excavation and construction of a monitoring well. These data are often required to provide guidance regarding the installation of specific components of the monitoring well. Guidance for lithologic sample collection and sample description is contained within Procedure 3-08, *Soil Sampling*.

5.0 Equipment and Supplies

Site groundwater: Use of site groundwater is preferred, since it can be extracted from the contaminant plume and will therefore emplace the emulsified oil along with the target contaminants and with water chemistry that corresponds to the existing conditions. This is especially important when groundwater is already anaerobic and bioaugmentation is going to be implemented. The use of groundwater also mitigates potential spreading of the plume in an adverse manner by maintaining a near neutral water balance. To use site groundwater, there must be extraction wells with sufficient capacity to supply the total injection flow rate; this approach works best when the extraction output can be plumbed directly to the proportional feed system and to the injection well array. This approach requires:

- Extraction Wells. These may subsequently become injection wells.
- Extraction Pumps. Submersible pumps with flow control, run-dry protection, and a suitable power source.
- Piping and Manifold. To connect extraction wells to dosing pumps.
- Power Supply. To operate the submersible extraction pump(s). If the site does not have power, one or more generator(s) are required. For refuelling, each generator will require secondary containment in the form of 6 mil visqueen underlying and surrounding each generator, and bermed around the edges to provide containment.

Potable Water: The use of potable water may be necessary for tight formations where sufficient groundwater cannot be supplied. Two options for a supply of potable water exist: 1) direct connection to a source of potable water (e.g., fire hydrant) during injections, or 2) storage of potable water in a tank or water truck. A direct connection with the water supply is preferable, but an alternate method is to use one or more large holding tanks or water truck and simply refill periodically. In locations where it is impractical to maintain a continuous connection to the source, this would allow longer operating times each day, as injections could get underway quicker and run longer if time was not required to set up and take down the fire hose each day. This hose could be rolled out to refill the tank during daily operation, as required. Use of a tank would depend on factors such as length of fire hose required, injection rate (which determines both how quickly a tank will be used up and pump requirements), and site access and utility considerations. The use of potable water will likely require:

- Fire Hose: Ensure that there is sufficient length of hose, including a few spare segments (to allow replacement of leaking connections or worn sections), to run from the elected hydrant to the staging area. Flow meter or hydrant access permit may be required to monitor the volume of hydrant water used. If the fire hose will cross an active transportation corridor, it may be necessary to procure a hose guard to protect it and to post proper traffic warning signs, as appropriate.
- Adaptor with Shut-Off Valve: This component is assembled from standard piping to allow connection of the supply line (i.e., fire hose) to the injection manifold or pump intake lines. It has female fire-hose thread on one end and reduces to a brass 2-inch male cam on the other, with a ball valve in between to allow quick shut-off of the water supply immediately adjacent to the injection equipment. A 2-inch spa hose completes the connection from the cam to the dosing system.
- Water Supply: If using clean water, and depending on the distance to the water supply, it is generally a good idea to plumb a simple tap off the adaptor so that there is a ready source of clean water near the work area.

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- Pump: If the water tank is used, a pump is required to transfer water from the water tank to the injection manifold. The transfer pump must have sufficient flow capacity to handle the targeted total injection rate, and must supply sufficient pressure to overcome losses in the manifold, lines, and formation.
- Power Supply to operate the transfer pump: If the site does not have power, a generator will be required. Each generator will require secondary containment for refuelling in the form of 6 mm visqueen underlying and surrounding each generator and will be bermed around the edges to provide containment.
- Water Truck: A vehicle specifically designed to carry water can be used if a direct connection source is impractical, and the injection wells are sufficiently spaced to require movement of a fixed tank during injections.

Groundwater Receiving Chamber: The central header will act to receive groundwater processed from the extraction pumps (or water supply source) and control the water pressure to the substrate amendment manifold. The chamber consists of a header made of standard 4-inch polyvinyl chloride (PVC) pipe with multiple inputs connected by cam-lok quick connectors (2-inch polypropylene) to the effluent lines from each extraction mmp. A pressure regulating valve is connected to the effluent side of the chamber to reduce downgradient pressure below 100 psi.

In-Line Filter: Two bag filters will be plumbed in parallel in-line, downstream of the groundwater receiving chamber to remove fines from the extracted groundwater. The bag filter must have a minimum of 200 gallons per minute capacity, and the filter element must have a nominal filter size of 74 micrometers at a minimum. Pressure gauges with 0 to 100 psi capacity will be plumbed on either side of the bag filters to monitor pressure drop across the filters. Each bag filter will have ball valves installed on either side to allow for isolation of the filter, for filter element changes.

Substrate Amendment Manifold: Rather than use a second transfer pump to move the substrate, the injection equipment features proportional feed pumps that are water-driven. The proportional feed pumps are designed to dose the amendment into the water stream in direct proportion to the water flow rate. A ball valve will be installed at the influent to the substrate amendment manifold to allow for isolation of the entire manifold. Individual pumps will be installed in parallel within the manifold. Upstream globe valves on each branch allow control over the flow rate going through each pump. Each pump will be installed on a bypass with ball valves on either side to allow for isolation of the injector for maintenance, and allow for flow of groundwater without amendment through the manifold for equipment flushing purposes. Flow meters with a minimum capacity of 50 gpm will be installed downstream of each pump on individual branches to monitor flow rates and ensure that the capacity of each pump (40 gpm) is not exceeded.

Distribution Manifold: A multi-channel distribution manifold splits the substrate-amended water stream between multiple lines, for delivery to multiple injection wells simultaneously. The distribution manifold consists of a ball valve at the influent end for isolation of the entire manifold a header made of standard 4-inch Schedule 40 PVC pipe, and a mechanical totalizing flow meter (bfass; minimum capacity up to 30 gpm) on each delivery channel. A needle valve is situated on the effluent side of each flowmeter to adjust the flow rate in each line independent of the other channels. The manifold outputs feature male cam-lok quick-connectors (2-inch plastic) threaded into each needle valve.

Amendment Delivery Lines: The lines that carry the amendment solution from the distribution manifold to the individual injection wells are 2-inch braided PVC hose with female cam-lock quick-connect fittings fixed to the hose ends with hose barbs and gear clamps. Most of the lines are 50-feet long, but can be readily connected together to cover longer runs as needed (requires a male/male adaptor to connect hoses).

Injection Wells: Injection well construction details are discussed in SOP 3-12, Drilling and Well Installation.

Well-Head Fittings: Each injection well requires a custom-built well-head fitting. The fitting consists of a PVC cross to which two ball valves (2-inch), a dual vacuum/pressure gauge (-20 to 30 psi) and a clear sight tube are attached. The sight tube is 2-inch clear BVC pipe. The well-head fitting is secured to the well with a Schedule 80 PVC flange fitting (9-inch outer diameter, 4-inch inside diameter. This flange fitting is bolted to the flange fitting installed on the well-head.

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6.0 Calibration or Standardization

Flow meters and pressure gauges should be factory calibrated and certified before being used on site. All meters should be returned to the manufacturer and re-calibrated between injection events.

7.0 Procedure

7.1 Background Information

The primary objectives of injection of bioremediation substrate are to 1) Create a passive biological barrier to enhance the breakdown of COCs in groundwater 2) Stop the continuing migration of COCs to downgradient receptors.

- Injections points should be spaced based upon the anticipated ROI to ensure complete coverage in the target remediation areas. Injection delivery points are pre-determined during the development of the work plan.
- Amount of substrate amendments are calculated prior to field implementation during the development of the WP. Rates of injection will depend on the aquifers ability to absorb the substrate without significant groundwater mounding or surface release in the adjacent monitoring wells and ground areas.
- Injections in multiple wells will take place simultaneously with the use of injection manifolds capable of regulating injection rates to individual wells.

The proper design of the injection system requires an understanding of site geology and hydrogeology, and knowledge of contaminant transport in subsurface materials.

7.2 Substrate Injection Procedures

Injection well Installation:

- Permanent injection wells will be installed following the procedures outlined in **SOP 3-12**, Monitoring/Injection Well Drilling, Installation and Abandonment
- At a number of injection points, substrate will be injected through direct push rods that will be used as temporary injection wells. Direct push rods will be removed and boreholes abandoned after the injection is complete.

Substrate Injection:

- substrate will be shipped to the site in plastic totes stored on pallets for ease of transport
- Potable or extracted groundwater will be used to mix the substrate in portable storage containers.
- Once the substrate has been mixed to the proper dilution, a trash pump will be used to continually mix the substrate and maintain the emulsification within the storage containers.
- A transfer pump will be used to transfer the mixture from the storage containers to the distribution manifold for injection into the permanent injection wells or temporary direct push injection points.
- A pressure gauge, flow totalizer and valve will be placed at the well-head to take continual measurements during injection. Once the target volume of substrate amendment has been injected to each well, the valve will be closed and injection will cease.
- An injection log will be maintained throughout the injection into each well. Injection logs will record the following information:
    - Well ID
    - Date
    - Start/End time

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- Elapsed time
- Volume of substrate amendment injected each interval
- Cumulative volume of substrate injected
- Flow rate
- Well-Head pressure

7.3 Injection Permitting

Subsurface injections shall be permitted in accordance with the regulations of the jurisdiction where the injection activity is occurring. Contact local regulatory agencies prior to any subsurface injection work.

The permit procedure may require permit fees, site inspections, and an application signed by a **registered professional geologist** or **engineer**. Permit requirements may impact field schedules and budgets. Provide documentation that all legal requirements have been met to the appropriate agencies prior to any injection activities.

8.0 Quality Control and Assurance

Substrate amendment injection activities must incorporate quality control measures to ensure:

- The correct volume of substrate is injected in each well.
- The formation is able to accept the volume of substrate at the flow rate it is being introduced at, and ensure that there is not excessive mounding in nearby monitoring wells, or excessive pressure at the injection well-head.
- Continually check the substrate mixture for signs of large oil droplets indicating the emulsification is breaking down and the oil is separating out.

Quality control measures typically include:

- Compare the readings on the well head totalizers to the the actual volume of substrate amendment removed from the injection storage containers
- Gauge nearby monitoring wells and piezometers to check for groundwater mounding caused by subsurface injections.
- If the substrate begins to come out of solution increase the rate of mixing.

These quality control measures provide:

- The injection process is working properly, substrate is being introduced to the subsurface as efficiently as possible, and reaching the targeted treatment zone.

9.0 Records, Data Analysis, Calculations

Injection data shall be recorded in the field notebook for the CTO and on an injection log. The **Field Manager** should provide a copy of this form to the **PM** for the project files.

Deviations from this procedure shall be documented in field records. Significant changes shall be approved by the **Program Quality Control Manager**.

10.0 Attachments or References

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Author	*Reviewer*	*Revisions (Technical or Editorial)*
Phil Granger, Field Manager	Chris Barr, Program Quality Manager	Rev 0 – Initial Issue

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Groundwater Monitoring

Procedure 3-14

1.0 Purpose and Scope

1.1 This standard operating procedure (SOP) describes the procedures for groundwater monitoring activities and establishes the method for collecting samples for water-borne contaminants and general groundwater chemistry. The objective is to obtain groundwater samples of aquifer conditions with as little alteration of water chemistry as possible.

1.2 This procedure is the Program-approved professional guidance for work performed by AECOM-Envirocon Joint Venture (AEJV) for task orders issued under the Performance Based Environmental Multiple Award Contract Number N62473-11-D-2231.

1.3 As guidance for specific activities, this procedure does not obviate the need for professional judgment. Deviations from this procedure while planning or executing planned activities must be approved in accordance with Program requirements for technical planning and review.

2.0 Safety

Depending upon the site-specific contaminants, various protective programs must be implemented prior to sampling the first well. All **field personnel** responsible for groundwater monitoring activities must review the site-specific health and safety plan (SSHSP) paying particular attention to the control measures planned for the well monitoring tasks. Conduct preliminary area monitoring of wells to determine the potential hazard to field sampling personnel. If significant contamination is visually observed, minimize contact with potential contaminants in both the vapor phase and liquid matrix through the use of respirators and disposable clothing.

In addition, observe standard health and safety practices according to the SSHSP. Suggested minimum protection during well sampling activities includes safety glasses, chemical-protective nitrile gloves, steel-toed boots, and an American National Standards Institute (ANSI)-standard hard hat. If significant contamination is anticipated on-site, respirators with appropriate cartridges and Tyvek® suits may be necessary depending on the contaminant concentrations, and shall always be available on site.

Depending upon the type of contaminant expected or determined in previous monitoring efforts, employ the following safe work practices:

2.1 **General Procedures**

- Avoid skin contact with and/or incidental ingestion of purge water.
- Wear long-sleeved protective gloves and splash protection (i.e., Saranex® or splash suits and face shields) as warranted.
- Use eye protection and gloves when handling acid or caustic preservatives.

2.2 **Volatile Organic Compounds**

- Avoid breathing constituents venting from the well by approaching upwind, and/or by use of respiratory protection.
- Presurvey the well head-space with a flame ionization detector/photoionization detector (PID) prior to sampling.

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- If monitoring results indicate organic vapors that exceed action levels as specified in the HSP, sampling activities may need to be conducted in Level C protection. At a minimum, use skin protection, such as Tyvek or other media that is protective against the encountered media.

2.3 **Physical Hazards associated with Well Sampling**

- To avoid lifting injuries associated with pump retrieval, use the large muscles of the legs, not the back. Use mechanical means of lifting whenever possible.
- Stay clear of all moving equipment, and avoid wearing loose fitting clothing.
- When using pocketknives for cutting purposes, cut away from yourself.
- To avoid slip/trip/fall (wet) conditions as a result of pump discharge, use textured boots/boot cover bottoms.
- To avoid heat/cold stress as a result of exposure to extreme temperatures and PPE, drink electrolyte replacement fluids (1 to 2 cups per hour is recommended) and, in cases of extreme cold, wear fitted insulating clothing.
- Be aware of restricted mobility due to PPE.
- Be aware of biological hazards such as snakes, ticks, spiders and bees when opening well vaults.

3.0 Terms and Definitions

None.

4.0 Training and Qualifications

4.1 The **Project Manager (PM)** is responsible for ensuring that monitoring well sampling activities comply with this procedure. The **PM** or **designee** shall review all groundwater sampling forms on a minimum monthly basis. The **PM** is responsible for ensuring that all personnel involved in monitoring well sampling shall have the appropriate education, experience, and training to perform their assigned tasks.

4.2 The **Program Quality Control Manager** is responsible for ensuring overall compliance with this procedure.

4.3 The **Field Manager** is responsible for ensuring that all field sampling personnel follow these procedures.

4.4 **Field personnel** are responsible for the implementation of this procedure. Minimum qualifications for **field personnel** require that one individual on the field team shall have a minimum of 6 months of experience with groundwater monitoring. Field personnel shall record all pertinent data collected during groundwater monitoring activities. If deviations from the procedure are required because of anomalous field conditions, they must first be approved by the **Program Quality Control Manager** and then documented in the field logbook and associated report or equivalent document.

5.0 Equipment and Supplies

- Groundwater sampling pump and control box
- Generator or other appropriate power source
- Sample containers
- PPE
- Decontamination equipment
- Environmental monitoring equipment including turbidity meter, PID, etc.

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6.0 Calibration or Standardization

Properly calibrate all equipment in a manner consistent with manufacturer's instructions. Calibration logs for all monitoring equipment should be filled out daily.

7.0 Procedure

7.1 Groundwater Sampling Procedures

Groundwater sampling procedures at a site shall include: (1) measurement of well depth to groundwater; (2) Decontamination of equipment, (3) assessment of the presence or absence of an immiscible phase; (4) assessment of purge parameter stabilization; and purging of static water within the well and well bore; and (5) obtaining a groundwater sample. Each step is discussed in sequence below. Depending upon specific field conditions, additional steps may be necessary. As a rule, at least 24 hours should separate well development and well sampling events, but specific regulations for local jurisdictions should be followed.

7.1.1 Measurement of Static Water Level Elevation

Measure the depth to standing water and the total depth of the well to the nearest 0.01 foot to provide baseline hydrologic data, to calculate the volume of water in the well, and to provide information on the integrity of the well (e.g., identification of siltation problems). Measure water depth in monitoring wells from the identified reference point for water level measurements whose location and elevation have been previously surveyed.

Before purging the well, measure water levels in all of the wells within the zone of influence of the well being purged. Measure water levels twice in quick succession and record each measurement. This will provide a water level database that describes water levels across the site at one time (a synoptic sampling). Measure the water level in each well immediately prior to purging the well.

The device used to measure the water level surface and depth of the well shall be sufficiently sensitive and accurate in order to obtain a measurement to the nearest 0.01 foot reliably. An electronic water level meter will usually be appropriate for this measurement; however, when the groundwater within a particular well is highly contaminated, an inexpensive weighted tape measure can be used to determine well depth to prevent adsorption of contaminants onto the meter tape. The presence of light, non-aqueous phase liquids (LNAPLs) and/or dense, non-aqueous phase liquids (DNAPLs) in a well requires measurement of the elevation of the top and the bottom of the product, generally using an interface probe. Water levels in such wells must then be corrected for density effects to accurately determine the elevation of the water table.

7.1.2 Decontamination of Equipment

Establish a decontamination station before beginning sampling. The station shall consist of an area of at least 4 feet by 2 feet covered with plastic sheeting and be located upwind of the well being sampled. The station shall be large enough to fit the appropriate number of wash and rinse buckets, and have sufficient room to place equipment after decontamination. One central cleaning area may be used throughout the entire sampling event. The area around the well being sampled shall also be covered with plastic sheeting to prevent spillage. Further details are presented in Procedure 3-06, *Equipment Decontamination*.

Decontaminate each piece of equipment prior to entering the well. Also, conduct decontamination prior to sampling at a site, even if the equipment has been decontaminated subsequent to its last usage. This precaution is taken to minimize the potential for cross-contamination. Additionally, decontaminate each piece of equipment used at the site prior to leaving the site. It is only necessary to decontaminate dedicated sampling equipment prior to installation within the well. Do not place clean sampling equipment directly on the ground or other contaminated surfaces prior to insertion into the well. Dedicated sampling equipment that has been certified by the manufacturer as being decontaminated can be placed in the well without on-site decontamination.

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7.1.3 Detection of Immiscible Phase Layers

Complete the following steps for detecting the presence of LNAPL and DNAPL before the well is evacuated for conventional sampling. Sample the headspace in the wellhead immediately after the well is opened for organic vapors using either a PID or an organic vapor analyzer, and record the measurements.

1. Lower an interface probe into the well to determine the existence of any immiscible layer(s), LNAPL and/or DNAPL, and record the measurements to the top and bottom of the layer.
2. Confirm the presence or absence of an immiscible phase by slowly lowering a clear bailer to the appropriate depth, then visually observing the results after sample recovery.
3. In rare instances, such as when very viscous product is present, it may be necessary to utilize hydrocarbon- and water-sensitive pastes for measurement of LNAPL thickness. This is accomplished by smearing adjacent, thin layers of both hydrocarbon- and water-sensitive pastes along a steel measuring tape and inserting the tape into the well. An engineering tape showing tenths and hundredths of feet is required. Record depth to water, as shown by the mark on the water-sensitive paste, and depth to product, as shown by the mark on the product-sensitive paste. In wells where the approximate depth to water and product thickness are not known, it is best to apply both pastes to the tape over a fairly long interval (5 feet or more). Under these conditions, measurements are obtained by trial and error and may require several insertions and retrievals of the tape before the paste-covered interval of the tape encounters product and water. In wells where approximate depths of air-product and product-water interfaces are known, pastes may be applied over shorter intervals. Water depth measurements should not be used in preparation of water table contour maps until they are corrected for depression by the product.
4. If the well contains an immiscible phase, a groundwater sample should not be collected. If the scope of work specifies a sample needs to be collected follow the procedures outlined below to sample the well. Consult the **Project Manager** and **Program Quality Control Manager** if this situation is encountered.

7.1.4 Purging Equipment and Use

The water present in a well prior to sampling may not be representative of in situ groundwater quality and shall be removed prior to sampling. Purging shall be accomplished by removing groundwater from the well at low flow rates using a pump. According to the U.S. Environmental Protection Agency (EPA) (EPA 1996), the rate at which groundwater is removed from the well during purging ideally should be less than 0.2 to 0.3 liters/min. The U.S. EPA further states that wells should be purged at rates below those used to develop the well to prevent further development of the well, to prevent damage to the well, and to avoid disturbing accumulated corrosion or reaction products in the well. The U.S. EPA also indicates that wells should be purged at or below their recovery rate so that migration of water in the formation above the well screen does not occur.

Realistically, the purge rate should be low enough that substantial drawdown in the well does not occur during purging. In addition, a low purge rate will reduce the possibility of stripping volatile organic compounds (VOCs) from the water, and will reduce the likelihood of mobilizing colloids in the subsurface that are immobile under natural flow conditions.

The **field sampler** shall ensure that purging does not cause formation water to cascade down the sides of the well screen. Wells shall not be purged to dryness if recharge causes the formation water to cascade down the sides of the screen, as this will cause an accelerated loss of volatiles. This problem should be anticipated. Water shall be purged from the well at a rate that does not cause recharge water to be excessively agitated unless an extremely slow recharging well is encountered where complete evacuation is unavoidable.

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In high yield wells (wells that exhibit 80 percent recovery in less than 2 hours), purging shall be conducted at relatively low flow rates and shall remove water from the entire screened interval of the well to ensure that fresh water from the formation is present throughout the entire saturated interval. In general, place the intake of the purge pump 2 to 3 feet below the air-water interface within the well to allow purging and at the same time minimize disturbance/overdevelopment of the screened interval in the well. During the well purging procedure, collect water level and/or product level measurements to assess the hydraulic effects of purging. Sample the well when it recovers sufficiently to provide enough water for the analytical parameters specified.

Low yield wells (those that exhibit less than 80 percent recovery in less than 2 hours) require one borehole volume of water to be removed. Allow the well to recover sufficiently to provide enough water for the specified analytical parameters, and then sample it.

Evaluate water samples on a regular basis during well evacuation and analyze them in the field preferably using in-line devices for temperature, pH (indicates the hydrogen ion concentration – acidity or basicity), specific conductivity, dissolved oxygen (DO), oxidation-reduction (redox) potential (ORP), and turbidity. Take at least four to six readings during the purging process, every 3 to 5 minutes. These parameters are measured to demonstrate that the natural character of the formation waters has been restored. Purging shall be considered complete when two or three consecutive field parameter measurements stabilize within approximately 10 percent. This criterion may not be applicable to temperature if a submersible pump is used during purging due to the heating of the water by the pump motor. Enter all information obtained during the purging and sampling process into a groundwater sampling log. Attachment 1 shows an example of a groundwater sampling log and the information typically included in the form. Whatever form is used, all blanks need to be completed on the field log during field sampling.

In cases where an LNAPL has been detected in the monitoring well, insert a stilling tube of a minimum diameter of 2 inches into the well prior to well purging. The stilling tube shall be composed of a material that meets the performance guidelines for sampling devices. Insert the stilling tube into the well to a depth that allows groundwater from the screened interval to be purged and sampled but that is below the upper portion of the screened interval where the LNAPL is entering the well screen. The goal is to sample the aqueous phase (groundwater) while preventing the LNAPL from entering the sampling device. To achieve this goal, insert the stilling tube into the well in a manner that prevents the LNAPL from entering the stilling tube.

One method of doing this is to cover the end of the stilling tube with a membrane or material that will be ruptured by the weight of the pump. A piece of aluminum foil can be placed over the end of the stilling tube. Slowly lower the stilling tube into the well to the appropriate depth and then attach it firmly to the top of the well casing. When the pump is inserted, the weight of the pump breaks the foil covering the end of the tube, and the well can be purged and sampled from below the LNAPL layer. Firmly fasten the membrane or material that is used to cover the end of the stilling tube so that it remains attached to the stilling tube when ruptured. Moreover, the membrane or material must retain its integrity after it is ruptured. Pieces of the membrane or material must not fall off the stilling tube into the well. Although aluminum foil is mentioned in this discussion as an example of a material that can be used to cover the end of the tube, a more chemically inert material may be required based on the site-specific situation. Thoroughly decontaminate stilling tubes prior to each use. Collect groundwater removed during purging, and store it on site until its disposition is determined based upon laboratory analytical results. Storage shall be in secured containers, such as U.S. Department of Transportation-approved drums. Label containers of purge water with the Program-approved IDW label or as required by state or federal regulations.

The following paragraphs list available purging equipment and methods for their use.

Bailers and Pumps

***Submersible Pump*:**

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A stainless steel submersible pump may be utilized for purging both shallow and deep wells prior to sampling the groundwater for volatile, semivolatile, and non-volatile constituents. For wells over 200 feet deep, the submersible pump is one of the few technologies available to feasibly accomplish purging under any yield conditions. For shallow wells with low yields, submersible pumps are generally inappropriate due to overpumpage of the wells (>1 gallon per minute), which causes increased aeration of the water within the well.

Steam clean or otherwise decontaminate the pump and discharge tubing prior to placing the pump in the well. The submersible pump shall be equipped with an anti-backflow check valve to limit the amount of water that will flow back down the drop pipe into the well. Place the pump intake approximately 2 to 3 feet below the air-water interface within the well and maintain it in that position during purging. Additionally, when pulling the pump out of the well subsequent to purging, take care to avoid dumping water within the drop pipe and pump stages back into the well.

***Bladder Pump*:**

A stainless steel and/or Teflon® bladder pump can be utilized for purging and sampling wells up to 200 feet in depth for volatile, semivolatile, and non-volatile constituents. Additionally, the bladder pump can be utilized for purging and obtaining groundwater samples overlain by an LNAPL layer as long as care is taken not to draw the product layer into the bladder pump. Use of the bladder pump is most effective in low to moderate yield wells where the pump can cause depression of the water table and allow significant inflow of fresh formation water.

Either compressed dry nitrogen or compressed dry air, depending upon availability, can operate the bladder pump. The driving gas utilized must be dry to avoid damage to the bladder pump control box. Decontaminate the bladder pump prior to use. Once purging is complete, collect the samples directly from the bladder pump.

***Centrifugal, Peristaltic, or Diaphragm Pump*:**

A centrifugal, peristaltic, or diaphragm pump may be utilized to purge a well if the water level is within 20 feet of ground surface. A new, or properly decontaminated, hose is lowered into the well and water withdrawn at a rate that does not cause excessive well drawdown. Place the hose bottom approximately 2 to 3 feet below the air-water interface and maintain it in that position during purging.

***Air Lift Pump*:**

Airlift pumps are not appropriate for purging or sampling.

***Bailer*:**

Avoid using a bailer to purge a well because it can result in overdevelopment of the well and create excessive purge rates. If a bailer must be used, decontaminate the bailer, bailer wire, and reel as described in Section 7.2.2 prior to its use. Teflon-coated cable mounted on a reel is recommended for lowering the bailer in and out of the well.

Lower the bailer below the water level of the well with as little disturbance of the water as possible to minimize aeration of the water in the well. One way to gauge the depth of water on the reel is to mark the depth to water on the bailer wire with a stainless steel clip. In this manner, less time is spent trying to identify the water level in the well. The **Program Quality Control Manager** shall approve use of bailers for purging monitoring wells in advance.

7.1.5 Monitoring Well Sampling Methodologies

Sampling Light, Non-Aqueous Phase Liquids (LNAPL):

Collect LNAPL, if present, prior to any purging activities. The sampling device shall generally consist of a dedicated or disposable bailer equipped with a bottom-discharging device. Lower the bailer slowly until contact is made with the surface of the LNAPL, and to a depth less than that of the immiscible fluid/water

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interface depth as determined by measurement with the interface probe. Allow the bailer to fill with LNAPL and retrieve it.

When sampling LNAPLs, drop bailers into a well and remove them from the well in a manner that causes as little agitation of the sample as possible. For example, the bailer should not be removed in a jerky fashion or be allowed to continually bang against the well casing as it is raised. When using bailers to collect LNAPL samples for inorganic analyses, the bailer shall be composed of fluorocarbon resin. Bailers used to collect LNAPL samples for organic analyses shall be constructed of stainless steel. The cable used to raise and lower the bailer shall be composed of an inert material (e.g., stainless steel) or coated with an inert material (e.g., Teflon).

Sampling Dense, Non-Aqueous Phase Liquids (DNAPL):

Collect DNAPL prior to any purging activities. The best method for collecting DNAPL is to use a double-check valve, stainless steel bailer, or a Kemmerer (discrete interval) sampler. The sample shall be collected by slow, controlled lowering of the bailer to the bottom of the well, activation of the closing device, and retrieval.

Groundwater Sampling Methodology:

The well shall be sampled when groundwater within it is representative of aquifer conditions and after it has recovered sufficiently to provide enough volume for the groundwater sampling parameters. A period of no more than 2 hours shall elapse between purging and sampling to prevent groundwater interaction with the casing and atmosphere. This may not be possible with a slowly recharging well. Measure and record the water level prior to sampling to demonstrate the degree of recovery of the well. Sampling equipment (e.g., especially bailers) shall never be dropped into the well, as this could cause aeration of the water upon impact. Additionally, the sampling methodology utilized shall allow for the collection of a groundwater sample in as undisturbed a condition as possible, minimizing the potential for volatilization or aeration. This includes minimizing agitation and aeration during transfer to sample containers.

Sampling equipment shall be constructed of inert material. Equipment with neoprene fittings, polyvinyl chloride (PVC) bailers, Tygon® tubing, silicon rubber bladders, neoprene impellers, polyethylene, and Viton® is not acceptable. If bailers are used, an inert cable/chain (e.g., fluorocarbon resin-coated wire or single strand stainless steel wire) shall be used to raise and lower the bailer. Generally, bladder and submersible pumps are acceptable sampling devices for all analytical parameters. Dedicated equipment is highly recommended for all sampling programs. The following text describes sampling methods utilizing submersible pumps, bladder pumps, and bailers.

If a flow through cell is used to collect field parameters be sure to remove it from the sampling discharge line before collecting the groundwater sample.

***Submersible Pumps*:**

When operated under low-flow rate conditions (100 to 500 milliliters [mL]/minute), submersible pumps are as effective as bladder pumps in acquiring samples for volatile organic analysis as well as other analytes. The submersible pump must be specifically designed for groundwater sampling (i.e., pump composed of stainless steel and Teflon, sample discharge lines composed of Teflon) and must have a controller mechanism allowing the required low flow rate. Adjust the pump rate so that flow is continuous and does not pulsate to avoid aeration and agitation within the sample discharge lines. Run the pump for several minutes at the low flow rate used for sampling to ensure that the groundwater in the lines was obtained at the low flow rate. Higher pumping rates than 100 to 500 mL/minute may be used when collecting samples to be analyzed for non-volatile constituents, if significant drawdown does not occur.

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***Bladder Pumps*:**

A gas-operated Teflon or stainless steel bladder pump with adjustable flow control and equipped with Teflon-lined tubing can be effectively utilized to collect a groundwater sample and is considered to be the best overall device for sampling inorganic and organic constituents. Operate positive gas displacement bladder pumps in a continuous manner so that they minimize discharge pulsation that can aerate samples in the return tube or upon discharge. If a bladder pump is utilized for the well purging process, the same bladder pump can also be utilized for sample collection after purging is complete.

When using a compressor, take several precautions. First, position the gasoline-operated compressor downwind of the well cap. Second, ground the engine block. This can be done by connecting a wire (with clips on either end) to the engine and to a stake that has been hammered into the ground. Third, ensure the purge water exiting the well is collected into a drum or bucket. Finally, connect the red compression hose from the well cap to the control box. Do not connect the compression hose from the compressor to the control box until after the engine has been started.

When all precautions are completed and the engine has been started, connect the compression hose to the control box. Slowly adjust the control knobs to discharge water in the shortest amount of time while maintaining a near constant flow. This does not mean that the compressor must be set to discharge the water as hard as possible. The optimal setting is one that produces the largest volume of purge water per minute (not per purge cycle) while maintaining a near constant flow rate.

Prior to sampling, adjust the flow rate (purge rate) to yield 100 to 500 mL/minute. Avoid settings that produce pulsating streams of water instead of a steady stream. Operate the pump at this low flow rate for several minutes to ensure that the groundwater being sampled is being withdrawn at the low extraction rate. The flow rate of 100 mL/minute must be obtained so as not to cause fluctuation in pH, pH-sensitive analytes, and the loss of volatile constituents. Higher flow rates can be used once the samples for the analysis of volatile components have been collected. At no time shall the sample flow rate exceed the flow rate used while purging. Preserve the natural conditions of the groundwater, as defined by pH, DO, specific conductivity, and redox.

For those samples requiring filtration, it is recommended to use an in-line high capacity filter after all nonfiltered samples have been collected.

***Bailers*:**

A single- or double-check valve Teflon or stainless steel bailer equipped with a bottom discharging device can be utilized to collect groundwater samples. Bailers have a number of disadvantages, however, including a tendency to alter the chemistry of groundwater samples due to degassing, volatilization, and aeration; the possibility of creating high groundwater entrance velocities; differences in operator techniques resulting in variable samples; and difficulty in determining where in the water column the sample was collected. Therefore, use bailers for groundwater sampling only when other types of sampling devices cannot be utilized for technical or logistical reasons. The **Program Quality Control Manager** must approve the use of bailers for groundwater sampling in advance.

Thoroughly decontaminate the bailer before being lowering it into the well if it is not a disposable bailer sealed in plastic. Collect two to three rinse samples and discharge them prior to acquisition of the actual sample. Each time the bailer is lowered to the water table, lower it in such a way as to minimize disturbance and aeration of the water column within the well.

The preferred alternative when using bailers for sampling is to use disposable Teflon bailers equipped with bottom-discharging devices. Use of disposable bailers reduces decontamination time and limits the potential for cross-contamination.

***Peristaltic Pumps*:**

A peristaltic pump is a type of positive displacement pump that moves water via the process of peristalsis. The pump uses a flexible hose fitted inside a circular pump casing. A rotor with cams

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compresses the flexible tube as the rotor turns, which forces the water to be pumped to move through the tube. In peristaltic pumps, no moving parts of the pump are in contact with the water being pumped. Displacement is determined by tube size, so delivery rate can only be changed during operation by varying pump speed. Peristaltic pumps are simple and quite inexpensive for the flow rates they provide. Peristaltic pumps use the vacuum-trap method to collect the groundwater sample. In this method, a pre-cleaned "transfer bottle" is connected between the peristaltic pump and the Teflon tubing in the well. As the air is pumped out of the transfer bottle, the vacuum created causes the transfer bottle to fill with groundwater. The water aliquot in the transfer bottle is used to fill the appropriate sample containers. See Attachment 2 for the "Low Flow Sampling Using Peristaltic Pump" procedure.

7.1.6 Sample Handling and Preservation

Many of the chemical constituents and physiochemical parameters to be measured or evaluated during groundwater monitoring programs are chemically unstable; therefore, preserve samples. The U.S. EPA document entitled, *Test Methods for Evaluating Solid Waste – Physical/Chemical Methods (SW-846)* (EPA 1997), includes a discussion of appropriate sample preservation procedures. In addition, SW-846 specifies the sample containers to use for each constituent or common set of parameters. In general, check with specific laboratory requirements prior to obtaining field samples. In many cases, the **laboratory** will supply the necessary sample bottles and required preservatives. In some cases, the **field sampling personnel** may add preservatives in the field.

Improper sample handling may alter the analytical results of the sample. Therefore, transfer samples in the field from the sampling equipment directly into the container that has been prepared specifically for that analysis or set of compatible parameters as described in the project-specific work plan. It is not an acceptable practice for samples to be composited in a common container in the field and then split in the laboratory, or poured first into a wide mouth container and then transferred into smaller containers.

Collect groundwater samples and place them in their proper containers in the order of decreasing volatility and increasing stability. A preferred collection order for some common groundwater parameters is:

1. VOCs and total organic halogens (TOX)
2. Dissolved gases, total organic carbon (TOC), total fuel hydrocarbons
3. Semivolatile organics, pesticides
4. Total metals, general minerals (unfiltered)
5. Dissolved metals, general minerals (filtered)
6. Phenols
7. Cyanide
8. Sulfate and chloride
9. Turbidity
10. Nitrate and ammonia
11. Radionuclides

When sampling for VOCs, collect water samples in vials or containers specifically designed to prevent loss of VOCs from the sample. An **analytical laboratory** shall provide these vials, preferably by the laboratory that will perform the analysis. Collect groundwater from the sampling device in vials by allowing the groundwater to slowly flow along the sides of the vial. Sampling equipment shall not touch the interior of the vial. Fill the vial above the top of the vial to form a positive meniscus with no overflow. No headspace shall be present in the sample container once the container has been capped. This can be checked by inverting the bottle once the sample is collected and tapping the side of the vial to

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dislodge air bubbles. Sometimes it is not possible to collect a sample without air bubbles, particularly water that is aerated. In these cases, the **field sampling personnel** shall note the problem to account for possible error. Cooling samples may also produce headspace, but this will typically disappear once the sample is warmed prior to analysis. In addition, if the samples are shipped by air, air bubbles form most of the time. **Field sampling personnel** shall note in the field logs any headspace in the sample container(s) at the time the sample was first transferred to the sample container at the wellhead. Likewise, the **analytical laboratory** shall note in the laboratory analysis reports any headspace in the sample container(s) at the time of receipt by the laboratory.

Special Handling Considerations:

Samples requiring analysis for organics shall not be filtered. Samples shall not be transferred from one container to another because this could cause aeration or a loss of organic material onto the walls of the container. TOX and TOC samples shall be handled and analyzed in the same manner as VOC samples.

Obtain groundwater samples to be analyzed for metals sequentially. One sample shall be obtained directly from the pump and be unfiltered. The second sample shall be filtered through a 0.45-micron membrane in-line filter. Both filtered and unfiltered samples shall be transferred to a container, preserved with nitric acid to a pH less than 2, and analyzed for dissolved metals. Remember to include a filter blank for each lot of filters used and always record the lot number of the filters. In addition, allow at least 500 mL of effluent to flow through the filter prior to sampling. Any difference in concentration between the total and dissolved fractions may be attributed to the original metallic ion content of the particles and adsorption of ions onto the particles.

Field Sampling Preservation:

Preserve samples immediately upon collection. Ideally, sampling containers will be pre-preserved with a known concentration and volume of preservative. For example, metals require storage in aqueous media at pH of 2 or less. Typically, 0.5 mL of 1:1 nitric acid added to 500 mL of groundwater will produce a pH less than 2. Certain matrices that have alkaline pH (greater than 7) may require more preservative than is typically required. An early assessment of preservation techniques, such as the use of pH strips after initial preservation, may therefore be appropriate. The introduction of preservatives will dilute samples and may require normalization of results. Guidance for the preservation of environmental samples can be found in the U.S. EPA *Handbook for Sampling and Sample Preservation of Water and Wastewater* (EPA 1982). Additional guidance can be found in other U.S. EPA documents (EPA 1992, 1996).

Field Sampling Log:

A groundwater sampling log provided as Attachment 1 shall document the following:

- Identification of well
- Well depth
- Static water level depth and measurement technique
- Presence of immiscible layers and detection method
- Well yield
- Purge volume and pumping rate
- Time that the well was purged
- Collection method for immiscible layers
- Sample identification numbers
- Well evacuation procedure/equipment
- Sample withdrawal procedure/equipment

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- Date and time of collection
- Well sampling sequence
- Types of sample containers used and sample identification numbers
- Preservative(s) used
- Parameters requested for analysis
- Field analysis data
- Sample distribution and transporter
- Field observations on sampling event
- Name of collector
- Climatic conditions including air temperature

8.0 Quality Control and Assurance

8.1 Monitoring well sampling activities must incorporate quality control measures to ensure that:

- Samples are representative of aquifer conditions and not standing well water.
- Proper decontamination procedures have been followed there is no cross contamination between wells or sites.
- Samples are collected in a method consistent with the analyses to be performed.
- Samples are transported to the laboratory following proper chain of custody (COC) procedures.

8.2 Quality control measures typically include:

- Calibration of monitoring equipment before sampling begins each day, and checking monitoring equipment with a standardized calibration solution at the end of the day.
- Following COC procedures, including keeping custody of the samples at all times, and properly filling out and relinquishing the COC to the laboratory.
- Collecting all required field quality control samples for laboratory analysis.

8.3 These quality control measures provide:

- A level of confidence that the data quality objectives (DQOs) for the project are achieved.

9.0 Records, Data Analysis, Calculations

Information collected during monitoring well sampling shall be documented on the groundwater sampling log form in indelible ink (Attachment 1). Copies of this information shall be sent to the **Project Manager** for the project files.

10.0 Attachments or References

10.1 Attachment 1 – Groundwater Sampling Log.

10.2 Attachment 2 – Low Flow Sampling Using Peristaltic Pump.

10.3 ASTM Standard D5088. 2008. *Standard Practice for Decontamination of Field Equipment Used at Waste Sites.* ASTM International, West Conshohocken, PA. 2008. DOI: 10.1520/D5088-02R08. www.astm.org.

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10.4 Environmental Protection Agency, United States (EPA). 1982. *Handbook for Sampling and Sample Preservation of Water and Wastewater.* EPA-600/4-82-029. Cincinnati: EPA Office of Research and Development, Environmental Monitoring and Support Laboratory.

10.5 EPA. 1992. *RCRA Groundwater Monitoring Draft Technical Guidance*. EPA/530/R-93/001. Office of Solid Waste. November.

10.6 EPA. 1996. *Ground Water Issue: Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*. EPA/540/S-95/504. Office of Solid Waste and Emergency Response. April.

10.7 EPA. 1997. *Test Methods for Evaluating Solid Waste, Physical/Chemical Method (SW-846)*. 3rd ed., Final Update IIIA. Office of Solid Waste. Online updates at: http://www.epa.gov/epaoswer/hazwaste/test/new-meth.htm.

10.8 NAVSEA T0300-AZ-PRO-010. *Navy Environmental Compliance Sampling and Field Testing Procedures Manual*. August 2009.

10.9 Procedure 3-06, *Equipment Decontamination*.

Author	*Reviewer*	*Revisions (Technical or Editorial)*
Phil Granger, Field Manager	Chris Barr Program Quality Control Manager	Rev 0 – Initial Issue

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Attachment 1

GROUNDWATER SAMPLING LOG

WELL NO.: _____ LOCATION: _____ PROJECT NO: _____

DATE: _____ TIME: _____ CLIMATIC CONDITIONS: _____

STATIC WATER LEVEL: _____ TOTAL DEPTH: _____

WELL PURGING: LENGTH OF SATURATED ZONE: _____ LINEAR FEET

VOLUME OF WATER TO BE EVACUATED: _____ GALS/LINEAR FEET X

_____ LINEAR FEET OF SATURATION X CASING VOLUMES = _____ GALS

METHOD OF REMOVAL: _____ PUMPING RATE: _____

WELL PURGE DATA:

DATE/ TIME	GALLONS REMOVED	pH	SP. COND.	DO	REDOX	TURBIDITY

SAMPLE WITHDRAWAL METHOD: _____

APPEARANCE OF SAMPLE: COLOR _____

TURBIDITY _____

SEDIMENT _____

OTHER _____

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES: _____

NUMBER AND TYPES OF SAMPLE CONTAINERS USED: _____

SAMPLE IDENTIFICATION NUMBER(S): _____

DECONTAMINATION PROCEDURES: _____

NOTES: _____

SAMPLED BY: _____

SAMPLES DELIVERED TO: _____ TRANSPORTERS: _____

DATE: _____ TIME: _____

CAPACITY OF CASING (GALLONS/LINEAR FOOT)
2”-0.16 • 4”-0.65 • 6”-1.47 • 8”-2.61 • 10”-4.08 • 12”-5.87

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Attachment 2

LOW FLOW SAMPLING USING PERISTALTIC PUMP

The following step-by-step procedures describe the process of purging with a peristaltic pump:

1. Cut a length of standard-cleaned Teflon® tubing, equal to the well depth plus an additional 5 to 10 feet. Enough tubing is needed to run from the ground surface up to the top of the well casing and back down to the bottom of the well. This will allow for operation of the pump at all possible water level conditions in the well.
2. Place one end of the tubing into the vacuum side of the peristaltic pump head. Proper sizing of the Teflon® and Silastic® or Tygon® tubing should allow for a snug fit of the Teflon® tubing inside the flexible tubing mounted in the pump head.
3. Run a short section of tubing (does not have to be Teflon®) from the discharge side of the pump head to a graduated bucket.
4. Place the free end of the Teflon® tubing into the well until the end of the tubing is just below the surface of the water column.
5. Secure the Teflon® tubing to the well casing or other secure object using electrician's tape or other suitable means. This will prevent the tubing from being lost in the well should the tubing detach from the pump head.
6. Turn on the pump to produce a vacuum on the well side of the pump head and begin the purge. Observe pump direction to ensure that a vacuum is being applied to the purge line. If the purge line is being pressurized, either switch the tubing at the pump head or reverse the polarity of the cables on the pump or on the battery.
7. If the pumping rate exceeds the recovery rate of the well, continue to lower the tubing into the well, as needed, until the drawdown stabilizes or the well is evacuated to dryness. If the pump is a variable speed peristaltic pump, and the water level in the well is being drawn down, reduce the speed of the pump in an attempt to stabilize the drawdown. If the well can be purged without evacuating the well to dryness, a sample with greater integrity can be obtained.
8. For wells which are not evacuated to dryness, particularly those with recovery rates equal to or very nearly equal to the purge rate, there may not be a complete exchange and removal of stagnant water in that portion of the water column above the tubing intake. For this reason, it is important that the tubing intake be placed in the very uppermost portion of the water column while purging.

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Attachment B
Land Use Control Remedial Design

(To be Provided at a Later Date)

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Attachment C
Construction Quality Assurance/Construction Quality Control Plan

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APPENDICES

A Construction Quality Control Checklists

B Submittal Register

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ACRONYMS AND ABBREVIATIONS

AEJV	AECOM-Envirocon Joint Venture
CAR	Corrective Action Report
CQA	Construction Quality Assurance
CQC	Construction Quality Control
CQMP	Construction Quality Management Plan
CTO	contract task order
DON	Department of the Navy
DCR	daily construction report
DFOW	definable feature of work
ESS	explosives safety submission
FCR	Field Change Request (FCR)
FCN	Field Change Notice
HSA	Hollow-stem auger
HSO	Health and Safety Officer
IRP	Installation Restoration Program
MCAS	Marine Corps Air Station
MPPEH	material potentially presenting an explosive hazard
NAVFAC SW	Naval Facilities Engineering Command Southwest
NCR	nonconformance report
PERMAC	Performance-Based Multiple Award Contract
PM	Project Manager
QA	quality assurance
QAO	Quality Assurance Officer
QC	quality control
RD/RA	Remedial Design/Remedial Action
RPM	Remedial Project Manager
UXO	unexploded ordnance

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1. Introduction

The Naval Facilities Engineering Command (NAVFAC) Southwest has contracted with the AECOM-Envirocon Joint Venture (AEJV) (N62473-11-D-2231) to support NAVFAC Southwest's Performance-Based Multiple Award Contract II (PERMAC II) Program. A Program Construction Quality Management Plan (CQMP) was developed to specifically address Section C, Statement of Work Part 5 Quality Control (AEJV 2011). Specifically, this CQMP presents the framework for quality control (QC) and quality assurance (QA) procedures to be followed during the implementation of contract task orders (CTOs) awarded to AEJV under PERMAC II.

Per the CQMP, this Construction Quality Assurance (CQA)/Construction Quality Control (CQC) Plan has been prepared as part of this Remedial Design/Remedial Action (RD/RA) Work Plan for the groundwater remedy to be implemented at Installation Restoration Program (IRP) Sites 1 and 2, former Marine Corps Air Station (MCAS) El Toro, California.

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2. Construction Quality Assurance/Construction Quality Control Plan

The CQA/CQC Plan presents the QC procedures to be followed during the groundwater remedial action implementation at IRP Sites 1 and 2. The purpose of this plan is to establish the framework within which QA/QC procedures will be implemented to assure that the completed site work meets design criteria, plans, and performance requirements.

2.1 POLICY

Consistent with the CQMP, the AEJV through the utilization of a QC program will strive to obtain uniform high quality materials and workmanship throughout all phases of procurement, fabrication, construction, and installation of equipment and facilities. To ensure this, the following principles will be observed:

- Assure the highest quality by maintaining supervised controls and written instructions governing contractor QC procedures and practices, establish clearly defined responsibility and authority for compliance, and thorough QC inspection and testing.
- Comply with contractual requirements, specifications, applicable standards, and the QC Plan.
- Compile accurate records of test certifications and other required documentation.
- The QC Manager will notify the Government of any quality discrepancies for immediate corrective action, and assure that corrective action is implemented properly.

2.2 CQC/CQA ORGANIZATION

The project organization for the groundwater remedial action implementation at IRP Sites 1 and 2 includes representatives from the Department of the Navy (DON) and contractor. The responsibilities of key personnel within each of these organizations are discussed in Section 8 of the RD/RA Work Plan, and the overall organization and relationships of these individuals are illustrated on Figure 8-1 of the RD/RA Work Plan.

2.3 MEETINGS

General meetings will be held throughout the implementation of the site work.

2.3.1 Kick-Off Meeting

Following receipt of the notice to proceed with the remedial action, a kick-off meeting may be held to discuss final project design and performance requirements provided in the RD/RA Work Plan. If the contractor determines a kick-off meeting is necessary, it shall be held prior to the remedial action and include the parties involved, including but not limited to the Remedial Project Manager (RPM), remedial action contractor's Project Manager (PM), Program/Project QC Manager and Project QC Engineer.

The purpose of a kick-off meeting is to establish lines of communication; review project design and performance requirements for completeness and clarity; begin planning for coordination of tasks; and anticipate problems that might cause difficulties and delays in construction. Guidelines regarding QA testing and problem resolution must be known and accepted by the parties. A person designated

at the beginning of the meeting shall document the meeting, and minutes shall be transmitted to the involved parties.

2.3.2 Preconstruction Meeting

A preconstruction meeting shall be held at the site prior to the start of the remedial action. At a minimum, the Navy RPM; and the contractor's PM, Health and Safety Officer (HSO), Project QC engineer, and Construction Field Manager shall attend the meeting.

2.3.3 Progress Meetings

Weekly progress meetings shall be held between the Navy RPM, and the remedial action contractor's PM, HSO, Project QC engineer, and Construction Field Manager. These meetings will include a discussion of current progress, planned activities for the next week, issues requiring resolution, and new business or revisions to the work. The remedial action contractor's representative shall keep minutes that document problems, decisions, action items, or questions arising at each of these meetings, and minutes shall be transmitted and approved by the parties present prior to the next week's meeting. If a particular matter remains unresolved at the end of this meeting, the Navy RPM shall be responsible for the resolution of the matter and the communication of the decision to the appropriate parties.

2.3.4 Readiness Reviews

During project planning, critical paths shall be identified and appropriate emphasis and resources applied to those activities to ensure successful project completion. The RPM or a designee, and the construction contractor will conduct readiness reviews prior to the start of major field activity to ensure the following:

- Applicable approvals have been obtained and notifications have been completed
- Adequately trained, qualified individuals will perform the work
- Appropriate plans and procedures are in place
- Adequate calibrated equipment are available
- Subcontractors meet project and subcontract requirements
- Other requirements for satisfactory performance of work have been met.

2.4 DOCUMENTATION

The Project QC engineer shall document that requirements in the CQC Plan have been addressed and satisfied. The following reports shall contain, at a minimum, identifying sheet numbers for cross-referencing and document control, date, project name, location, descriptive remarks, data sheets, inspection activities, and signatures of the designated authorities with the concurrence of the Project QC Manager.

2.4.1 Daily Reports

The Project QC engineer shall complete a Daily Construction Report (DCR) outlining activities for that day. The report shall at a minimum consist of field notes, observations, test data sheets, construction problems, health and safety meeting sign-in sheet, and solution data sheets. A summary of supporting data sheets and final testing results shall be required upon completion of the remedial action.

2.4.2 Nonconformance Reports

Nonconformance reports (NCRs) will be used to alert responsible personnel of problem areas and nonconforming items. Such occurrences will be recorded separately on individual nonconformance reports. The Project QC engineer will inform the Navy RPM of materials or workmanship that do not meet a specified design. At the instruction of the Navy RPM, the Project QC engineer will provide a written NCR with problems listed, referring to specific inspection data sheets where the problem is identified. Upon correction, the NCR shall be updated with actions taken and test data that prove the problem was corrected. The updated NCR shall be routed to the Navy RPM for concurrence.

2.4.3 Field Change Requests and Field Change Notices

Requests for changes to the project design and performance requirements shall be referred to the Navy RPM using Field Change Request (FCR) and Field Change Notice (FCN) forms. These will be reviewed, evaluated, documented, and controlled by procedures agreed upon between the Navy RPM and the remedial action contractor. The Navy RPM will approve the design changes prior to implementation.

Requests for modifications to the CQC Plan shall be made by memorandum to the Navy RPM.

If during the course of the remedial action, questions arise regarding interpretation of the contractual requirements, the Project QC engineer will contact the Contracting Officer. The Project QC engineer will document clarification of the drawings in a memorandum or teleconference records, and route clarification documentation to the Contracting Officer and Navy RPM for concurrence, then to project files for the record.

2.4.4 Test Reports

The Project QC engineer will maintain the records of laboratory and field testing performed on soil/groundwater. Test results will be summarized by the Project QC engineer on an ongoing basis, and submitted with the weekly progress reports.

2.4.5 Progress Reports

Progress reports will be prepared by the Project QC engineer and submitted to the Navy RPM on a weekly basis. These reports provide an overview of remediation progress to date and explanations of deviations from the project design and performance requirements specified in the RD/RA Work Plan and the contract. Deviations will be documented using the field change procedures described above. Problems or deficiencies encountered during construction, actions taken to correct the situation, a summary of weather conditions, health and safety documentation, and a brief summary of anticipated work for the following week will be included in the report. Daily reports, NCRs, FCRs, FCNs, and test reports will be summarized and included in progress reports, along with a copy of the minutes of the weekly progress meeting. The QC engineer will be responsible for distributing progress reports to the Navy RPM.

2.4.6 Record Drawings

As construction proceeds, the remedial action contractor shall maintain a set of record drawings along with changes made to the drawings. At the completion of construction, record drawings shall be prepared to document as-built conditions, including as-built utilities. The drawings shall be signed and sealed by a Professional Engineer registered in the State of California. The final record drawings will be reviewed and approved by the Navy RPM.

2.4.7 Quality Control Certifications

The Project QC engineer is required to provide signed QC certification statements on daily reports, attesting that, except for those items listed in the NCRs, the work is in compliance with project design and performance requirements specified in the RD/RA Work Plan and the contract. Upon completion of work under the contract, the Project QC Manager shall provide the DON with a certification attesting that the work has been completed, inspected, and tested, and is in compliance with the contract.

2.4.8 Construction Completion Report

At the completion of the project, the remedial action contractor will submit a Construction Completion Report to the Navy RPM. This report will include the daily reports, NCRs, test reports, progress reports, record drawings, and QC certifications. The Project QC Manager shall certify that the Construction Completion Report is correct and accurate. The final documentation should emphasize that areas of responsibility and lines of authority were clearly defined, understood, and accepted by parties involved in the project.

2.4.9 Document Control

The Project QC engineer will distribute the following documents to the Navy RPM:

- FCRs and FCNs
- Test reports
- Progress reports
- Record drawings
- QC certificates
- Construction Completion Report

The CQC documentation should be maintained under a document control procedure. Portions of the document(s) that are modified must be communicated to and agreed upon by the parties involved. The Project QC engineer will maintain a library of documents on-site using an indexing procedure to keep them organized and easily accessible. This library will include copies of the RD/RA Work Plan and statements of work, as well as the documentation listed in this section. Duplicate records shall be kept at a different location to avoid loss of this valuable information.

Once construction is complete, the DON shall store the document originals. In addition, a Construction Completion Report documenting the construction will be prepared and submitted to the Navy RPM. The report will include a compilation of test reports, progress reports, and record drawings.

2.5 QUALITY ASSURANCE/QUALITY CONTROL

2.5.1 Submittals

Submittals (Appendix B) will be prepared by the contractor with the assistance of appropriate subcontractors and suppliers. Submittals shall be transmitted to the Navy RPM or the Program QC Manager who will have approval authority.

2.5.2 Field Changes

FCRs and FCNs shall be prepared by the contractor and approved in accordance with Section 2.4.3.

2.5.3 Procurement

Procurement for major components and subcontracting for special services will be performed in accordance with the general contract. The procurement procedure shall require that adequate documentation and control take place to ensure the following:

- Procurement complies with approved purchasing procedures.
- Proposals have been reviewed for technical quality to verify compliance with project requirements.
- Management has reviewed the subcontractor selection process and contract changes.

The documentation for major procurements will include the following as appropriate:

- A statement of the scope of work to be performed.
- Technical requirements including, where necessary, reference to construction/manufacturing drawings, codes, standards, regulations, procedures, or instructions.
- Identification of reviews, tests, inspections, or other acceptance requirements for monitoring and evaluating the supplier's performance.
- Requirements for a documented CQC program commensurate with the type and use of the service or item, and that the appropriate CQC program requirements have been incorporated into sub-tier procurement document.
- Specification of submittals, including samples or material certificates to Navy RPM for information and review. A schedule for record submittal will also be specified.

2.5.4 Construction Monitoring and Testing

Construction activities shall be documented through the use of a DCR, as discussed in Section 2.4.1. Various inspection and monitoring tasks will be required during construction, and are discussed below.

Inspection and Surveillance

To confirm construction quality and maintain compliance with contract documents, the project QC engineer or designated representative shall conduct monitoring and surveillance during the remedial action activities on a daily basis. Developed based on the final design drawings, the CQC Plan will be reviewed by the DON to confirm conformance with the quality requirements necessary to successfully complete the project. In general, the QC engineer will carry out the following phased inspections and surveillance for each definable feature of work (DFOW):

- **Preparation Phase.** Review drawings, Work Plan, applicable codes, standards, and submittals to ensure compliance, product compatibility, dimensions, and constructability of methods and materials for the work. This includes a review of the scheduled activities as related to weather constraints and material availability, inspection and testing requirements, transportation, and reporting of test results prior to work.
- **Initial Phase.** Provide QC surveillance and inspection of construction to verify that appropriate types of construction materials are used, correct volumes or quantities are installed, and that construction materials are installed and tested according to design drawings and the Work Plan. Prepare daily reports, progress reports, or other reports, as appropriate, to include work performed, construction quality, change requests, personnel, equipment utilization, testing, and special instructions received.

- **Follow-up Phase.** Prior to completion and acceptance of work, ascertain that testing has been completed, workmanship is adequate, and that materials are functional, as specified; verify that deliverables are submitted; and confirm correction of inspection deficiencies.

The checklists for each DFOW for the remedial action implementation at IRP Sites 1 and 2 are presented in Attachment A.

Construction activities associated with the remedial action implementation will require periodic inspection and surveillance to ensure quality. Items requiring inspection/testing and surveillance include, but are not limited to, the following:

- **Biological Reconnaissance** – Three biological reconnaissance visits will be conducted at IRP Sites 1 and 2 prior to groundwater drilling activities to provide compliance with the requirements of the Migratory Bird Treaty Act and the informal Section 7 consultation for IRP Site 1 and the formal Section 7 consultation for IRP Site 2 between the Navy and the United States Fish and Wildlife Service.
- **Site Preparation** – Several of the proposed groundwater monitoring wells at IRP Site 2 are within Borrego Wash, which is an ephemeral stream. These wells are proposed to be advanced in soft sand. As a result, some site preparation may be required prior to mobilizing a drill rig to the locations, including placing gravel to provide adequate access for the drill rig.
- **Geophysical Survey of All Proposed Drilling Locations** – At all proposed groundwater well locations at IRP Site 2 and between IRP Sites 1 and 2, geophysical clearance will be conducted to verify that no underground utilities are present. A California-licensed geophysicist will utilize three techniques (magnetic, electromagnetic, and ground-penetrating radar) to search for anomalies that could indicate underground utilities.

  There are no underground utilities present at IRP Site 1. However, due to the potential for encountering material potentially presenting an explosive hazard (MPPEH), and in accordance with the applicable explosives safety submission (ESS) for the site (DON 2008), at all locations within IRP Site 1, anomaly avoidance techniques will be employed. This will involve unexploded ordnance (UXO) technician-qualified personnel, which will utilize visual as well as magnetic techniques to verify that no metallic objects are present at the location. The UXO technician will conduct a subsurface geophysical survey of all proposed intrusive locations utilizing hand-held instruments. If an anomaly is detected, all intrusive activities will be moved to a location where no anomalies are detected.
- **Drilling and Development of Groundwater Injection and Monitoring Wells** – The remedial action contractor will utilize the services of a drilling subcontractor to install groundwater injection and groundwater monitoring wells at IRP Site 1 and IRP Site 2, and at locations between the two sites. Hollow-stem auger (I) drilling techniques will be used.
- **Substrate Injection** – Substrate will be injected into selected wells to enhance reducing conditions and promote perchlorate degradation. An injection subcontractor will conduct the injections, which may include pumping from adjacent wells to create a recirculation loop of extraction and injection.
- **Land Survey of Well Locations** – The remedial action contractor will utilize the services of a land surveyor to survey the locations of all groundwater wells installed at IRP Sites 1 and 2.

The construction observation, and testing for CQC for above items are described below.

Construction Observation. The QC engineer or designated representative shall observe construction activities to verify that the project design presented in the RD/RA Work Plan and Contract are met. The project QC engineer shall report nonconformance to the Navy RPM. The Navy RPM will issue stop work notices only for major nonconformance items (i.e., those that affect the integrity and intent of the action, or when worker safety is compromised).

Defects and Repairs. The QC engineer shall assess the nature and extent of defects identified during the remedial action implementation. The QC engineer shall notify the Navy RPM after the extent and nature of the defect has been identified. A work deficiency meeting may be held as needed between the project QC engineer, RPM, and other necessary parties to address the problem.

The contractor shall correct deficiencies to meet the project design and performance requirements presented in the RD/RA Work Plan and Contract. If weather conditions affect work or project design and performance requirements cannot be met, the project QC engineer shall develop and present suggested solutions to the Navy RPM for approval. Tests, retests, and corrections will be documented in a report prepared after the field activities are completed. The QC engineer shall observe repairs and report noncompliance in writing to the Navy RPM.

Testing Requirements

QC testing shall be conducted in accordance with the applicable sections of the design presented in the RD/RA Work Plan for various tasks performed as part of the remedial action and the approved CQC Plan. Field and laboratory tests shall be conducted prior to or during construction as required by the RD/RA Work Plan. Sampling and testing procedures shall be observed and documented by the QC engineer. Reporting and documentation shall be in accordance with the approved CQC plan and Sampling and Analysis Plan.

2.6 DOCUMENT AND PROJECT RECORD CONTROL

A record system shall be implemented that designates responsibility for document, manual, and record management and provides for organization, filing, control, storage, and transfer of project records, including electronic media associated with the site work.

2.6.1 Drawings and Plans

Pertinent construction documents shall be controlled in the field office to ensure that correct and applicable documents are available at locations where related activities are to be performed. Documents requiring control include, but are not limited to, work plans, QA/QC plans, procedures and related forms, inspection plans, and testing plans. These documents include or reference appropriate quantitative or qualitative acceptance criteria for determining that prescribed tasks have been satisfactorily accomplished.

Copies of these documents will be issued to project personnel and subcontractors. The contractor shall be responsible for the following additional items:

- Maintaining document control logs (registers) listing the current revision to each document
- Logging and transmitting FCRs and FCNs for approval
- Receiving, controlling, and distributing approved field-generated changes such as FCRs and FCNs
- Maintaining a neat and well organized field filing system
- Maintaining duplicate copies of field-generated forms for filing at the program office

- Verifying that newly received documents are distributed to appropriate personnel and subcontractors

Revisions other than minor corrections or editorial changes shall require the same level of review and approval as the original and shall be accompanied by a description of the changes.

2.6.2 Records Administration

Records administration by the contractor shall follow the following guidelines:

- Records that furnish documentation or evidence of quality shall be identified in the procedures, plans, technical procedures, and procurement documents.
- Records shall be legible, identifiable, and retrievable. Record documents shall be considered valid records only if stamped, initialed, or signed, and dated by authorized personnel or otherwise authenticated.
- The original recorded data shall be written in waterproof ink. No accountable serialized documents are to be destroyed or discarded, even if they are illegible or contain inaccuracies that require a replacement document. If an error is made on an accountable document assigned to an individual, that individual shall make corrections by making a line through the error (initialed) and entering the correct information. The erroneous information shall not be obliterated. The person who made the entry shall correct subsequent error discovered on an accountable document. Subsequent corrections must be initialed and dated.
- A record indexing system shall be established that provides sufficient information to permit identification of the record and the item(s) or activity(ies) to which it applies.

2.6.3 Records Receipt

The QC engineer shall be responsible for reviewing the records upon receipt to verify that they meet requirements for completeness, legibility, identification, and applicable requirements prior to entry into the project field files.

2.6.4 Storage, Preservation, and Safekeeping

During site preparation fieldwork, copies of pertinent QA/QC plans, work plans, and design and construction records will be stored in a designated field office at the site. Upon completion of the project, the records shall be transferred to the DON or as directed.

2.6.5 Retrieval, Transfer, and Disposition

Project records shall be accessible to the DON and authorized representatives. Project records shall be maintained until the end of the contract and then transferred to the DON, unless otherwise directed.

2.7 QUALITY ASSURANCE AUDITS

A planned systematic auditing program shall be implemented during the remedial action implementation at IRP Sites 1 and 2 to gather adequate information through observation, inspection, and inquiry to assess the quality of the activity being performed. In addition, based on the deficiencies and concerns discovered from the audit (if any), management controls related to the activity will be assessed and recommendations for improvement will be made. The audits shall assess the effectiveness of the implementation of the CQC Plan. The Project QC Manager shall be responsible for planning and selecting an audit team, including appropriate technical specialists to perform the audit and report audit findings based on the work elements being audited.

During the audit, objective evidence will be examined to determine compliance with requirements. Each auditor records on the checklist the objective evidence, processes witnessed, QC implemented, personnel interviewed, and other activities witnessed. When deficiencies are encountered, the supervisor of the affected work item will be notified immediately. If deficiencies are corrected prior to completion of the audit, the resolution will be recorded on the audit checklist. If follow-up is required to identify the extent of the problem or implement resolution, the deficiency will be identified as an audit finding and recorded on a Corrective Action Report (CAR) form. Distinction should be made between systematic deficiencies and isolated problems representing a mistake.

Audit results shall be documented in an audit report prepared by the audit team leader. The report will be distributed to the PM or other appropriate personnel, including the Navy RPM and Naval Facilities Engineering Command Southwest (NAVFAC SW) Quality Assurance Officer (QAO).

The Project QC Manager is responsible for monitoring the status of corrective actions and verifying completion. When required corrective actions have been completed, the Project QC Manager shall complete applicable sections of the CAR form. Completed CAR forms will be distributed to the same personnel as the original audit report.

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3. References

AEJV. 2011. *Program Construction Quality Management Plan*. September.

———. 2012. *Draft, Remedial Design/Remedial Action Work Plan Installation Restoration Program Sites 1 and 2, Former Marine Corps Air Station, El Toro, California.* May.

Department of the Navy. 2008. *Explosives Safety Submission. Munitions Characterization, Installation Restoration Program Site 1, Explosive Ordnance Disposal Training Range, Former Marine Corps Air Station El Toro, California.* September.

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Appendix A
Construction Quality Control Checklists

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Definable Features of Work – Remedial Action Implementation at IRP Sites 1 and 2

- Site Preparation
- Drilling and Installation of Wells
- Substrate Injection

The checklists for each of the above-mentioned definable features of work are presented in the following tables.

PREPARATORY PHASE CHECKLIST	
Construction Contract Number	
Project Name	Remedial Action Implementation at IRP Sites 1 and 2, Former MCAS El Toro, CA
Site ID	IRP Sites 1 and 2
Date Checklist Completed	
Definable Feature of Work	**Site Preparation**

#	*Item*	*Comments*
Submittals Review and Approval		
1.	Is the Remedial Design/Remedial Action (RD/RA) Work Plan approved? If not, identify the items that have not been approved.	Yes No
2.	Is the Health and Safety Plan approved? If not, identify the items that have not been approved.	Yes No
Materials/Services Procurement		
3.	Are all the records including site plans, utility layouts, and as-built drawings available? If not, list the missing items and actions taken to obtain them?	Yes No
4.	Is the Geophysical subcontractor selected?	Yes No
5.	Have the decontamination area supplies been procured?	Yes No
6.	Has the UXO Technician for providing surface clearance selected	Yes No
Project Planning Documents/Field Procedures Review		
7.	Has the RD/RA Work Plan been provided to the geophysical subcontractor?	Yes No
8.	Have the site security and decontamination procedures been discussed?	Yes No
9.	Are there any variances from the procedures specified in the RD/RA Work Plan and project Scope of Work? If yes, list the variances.	Yes No
10.	Are the variances acceptable? If not, explain how unacceptable variances were resolved.	Yes No
Other Preparatory Work		

#	Item	Comments
11.	Are the boundaries clearly marked for conducting geophysical surveys?	Yes No
12.	Does a review of record drawings show the location of utilities within the boundary of the Project Area? List identified utilities.	Yes No
Health and Safety		
13.	Is the Health and Safety Plan transmitted to the geophysical subcontractor?	Yes No

INITIAL PHASE CHECKLIST	
Construction Contract Number	
Project Name	Remedial Action Implementation at IRP Sites 1 and 2, Former MCAS El Toro, CA
Site ID	IRP Sites 1 and 2
Date Checklist Completed	
Definable Feature of Work	**Site Preparation**

#	*Item*	*Comments*
Equipment Checks		
1.	Has the subcontractor performed calibration check on the instruments used for geophysical survey?	Yes No
2.	List issues (if any) with instruments and field methods, which needed to be resolved.	
3.	Do the site security materials conform to design provided in the RD/RA Work Plan and project Scope of Work? List deficiencies and corrective actions undertaken.	Yes No
Preliminary Work		
4.	Have the utility locations identified based on the records review tentatively been identified at the site prior to geophysical survey?	Yes No
5.	Is the location of decontamination area clearly marked?	Yes No
6.	Are the proposed work locations cleared by the UXO Technician?	Yes No
Health and Safety		
7.	Have the site personnel participated in the site-specific health and safety orientation?	Yes No
8.	Is adequate personnel protective equipment identified for utility clearance in the site-specific health and safety plan available? List missing items and actions taken to obtain them.	Yes No

FOLLOW-UP PHASE CHECKLIST	
Construction Contract Number	
Project Name	Remedial Action Implementation at IRP Sites 1 and 2, Former MCAS El Toro, CA
Site ID	IRP Sites 1 and 2
Date Checklist Completed	
Definable Feature of Work	**Site Preparation**

#	*Item*	*Comments*
Field Quality Control		
1.	Have the utility lines been clearly marked at the site based on the review of record drawings and geophysical surveys?	Yes No
Inspections/Tests		
2.	Have the representatives from utility companies inspected/marked any utility lines on-site? List inspection dates and comments received.	Yes No
3.	Inspect decontamination area, and site security and measures for conformance with the RD/RA Work Plan and project Scope of Work. List any deficiencies/variances encountered and corrective actions undertaken.	
4.	Inspect temporary storage/staging areas. List any deficiencies encountered and actions taken to remove the deficiencies.	
5.	Has biological reconnaissance visit been conducted?	Yes No
Submittals		
6.	Has the Underground Service Alert (Dig Alert) been contacted? Provide date Dig Alert was contacted and confirmation received?	Yes No
Health and Safety		
7.	List any safety violations and corrective actions taken.	

PREPARATORY PHASE CHECKLIST	
Construction Contract Number	
Project Name	Remedial Action Implementation at IRP Sites 1 and 2, Former MCAS El Toro, CA
Site ID	IRP Sites 1 and 2
Date Checklist Completed	
Definable Feature of Work	**Drilling and Installation of Wells**

#	*Item*	*Comments*
Submittals Review and Approval		
1.	Is the RD/RA Work Plan approved? If not, identify the items that have not been approved.	Yes No
2.	Is the Health and Safety Plan approved? If not, identify the items that have not been approved.	Yes No
Materials/Services Procurement		
3.	Is the drilling/installation equipment mobilized to the site? If not, list missing items and actions taken to obtain them.	Yes No
4.	Is the Well installation SOP reviewed by the subcontractor?	Yes No
Equipment Storage		
5.	Is the equipment storage area established?	Yes No
6.	Is all the equipment stored properly in a designated storage area? If not, what corrective actions are taken?	Yes No
Project Planning Documents/Field Procedures Review		
7.	Is the RD/RA Work Plan or pertinent portions of the Work Plan transmitted to the subcontractor and /or field personnel?	Yes No
8.	Are the drilling/installation procedures discussed?	Yes No
9.	Are there any variances from the drilling/installation procedures specified in the RD/RA Work Plan and project Scope of Work? If yes, list the variances.	Yes No
10.	Are the variances acceptable? If not, explain how unacceptable variances were resolved.	Yes No
Other Preparatory Work		

#	Item	Comments
11.	Are the drilling locations of clearly marked with stakes or paint to facilitate implementation? If not, explain.	Yes No
12.	Was any hand digging required to confirm the depths of certain utilities? If yes, list the utility along with its depth.	Yes No
13.	Are all the utilities within the drilling terminated/abandoned? If not, explain.	Yes No
Health and Safety		
14.	Is the Health and Safety Plan transmitted to the subcontractor and/or field personnel?	Yes No

INITIAL PHASE CHECKLIST	
Construction Contract Number	
Project Name	Remedial Action Implementation at IRP Sites 1 and 2, Former MCAS El Toro, CA
Site ID	IRP Sites 1 and 2
Date Checklist Completed	
Definable Feature of Work	**Drilling and Installation of Wells**

#	*Item*	*Comments*
Materials/Equipment Checks		
1.	Is the drilling/installation equipment of adequate capability and capacity to perform designated task? If not, what action is taken?	Yes No
Health and Safety		
2.	Have the site personnel participated in the site-specific health and safety orientation?	Yes No
3.	Is the drilling/installation equipment inspected for fuel leaks, and satisfactory operation of safety features? List deficiencies and corrective actions undertaken.	Yes No
4.	Is adequate personnel protective equipment identified in the site-specific health and safety plan available? List missing items and actions taken to obtain them.	Yes No
5.	Are the proposed work locations cleared by the UXO Technician?	Yes No

FOLLOW-UP PHASE CHECKLIST	
Construction Contract Number	
Project Name	Remedial Action Implementation at IRP Sites 1 and 2, Former MCAS El Toro, CA
Site ID	IRP Sites 1 and 2
Date Checklist Completed	
Definable Feature of Work	**Drilling and Installation of Wells**

#	*Item*	*Comments*
Field Quality Control		
1.	Is the drilling/installation of wells in accordance with the procedures specified in the RD/RA Work Plan? If not, explain.	Yes No
2.	Are the locations of the wells drilled surveyed by a registered Land Surveyor?	Yes No
Health and Safety		
3.	Are all safety equipment including eyewash unit, fire extinguisher, and safety devices on drilling/installation equipment operating satisfactorily? List any deficiencies and corrective actions undertaken.	Yes No
4.	List any safety violations and corrective actions taken.	

PREPARATORY PHASE CHECKLIST	
Construction Contract Number	
Project Name	Remedial Action Implementation at IRP Sites 1 and 2, Former MCAS El Toro, CA
Site ID	IRP Sites 1 and 2
Date Checklist Completed	
Definable Feature of Work	**Substrate Injection**

#	*Item*	*Comments*
Submittals Review and Approval		
1.	Is the RD/RA Work Plan approved? If not, identify the items that have not been approved.	Yes No
2.	Is the Health and Safety Plan approved? If not, identify the items that have not been approved.	Yes No
3.	Is the Substrate Injection Design and material (including MSDs) submitted and approved? If not, list actions taken.	Yes No
Materials/Services Procurement		
4.	Is the substrate satisfying the selected design?	Yes No
5.	Is there water available onsite for field activities? If not, what corrective actions are taken?	Yes No
Project Planning Documents/Field Procedures Review		
6.	Have the scope and procedures for substrate injection been discussed with the subcontractor and field personnel?	Yes No
7.	Are there any variances from the approved procedures specified in the RD/RA Work Plan and project Scopes of Work? If yes, list the variances.	Yes No
8.	Are the variances acceptable? If not, explain how unacceptable variances were resolved.	Yes No
Health and Safety		
9.	Is the Health and Safety Plan transmitted to the subcontractors/field personnel?	Yes No

INITIAL PHASE CHECKLIST	
Construction Contract Number	
Project Name	Remedial Action Implementation at IRP Sites 1 and 2, Former MCAS El Toro, CA
Site ID	IRP Sites 1 and 2
Date Checklist Completed	
Definable Feature of Work	**Substrate Injection**

#	*Item*	*Comments*
Materials/Equipment Checks		
1.	Is the substrate injection/storage/mixing equipment of adequate capability and capacity to perform designated tasks If not, list actions taken.	Yes No
2.	Does the substrate conform to design provided in the RD/RA Work Plan and project Scope of Work? List deficiencies and corrective actions undertaken.	Yes No
3.	Is the substrate injection/storage/mixing equipment thoroughly decontaminated?	Yes No
Health and Safety		
3.	Have the site personnel participated in the site-specific health and safety orientation?	Yes No
4.	Is adequate personnel protective equipment identified in the health and safety plan, available? List missing items and action taken to obtain them.	Yes No

FOLLOW-UP PHASE CHECKLIST	
Construction Contract Number	
Project Name	Remedial Action Implementation at IRP Sites 1 and 2, Former MCAS El Toro, CA
Site ID	IRP Sites 1 and 2
Date Checklist Completed	
Definable Feature of Work	**Substrate Injection**

#	*Item*	*Comments*
Field Quality Control/ Inspections / Tests		
1.	Are the following tests/checks/measurements performed per the RD/RA Work Plan: Substrate material and quantity, and any additional testing. If not, explain.	Yes No
2.	Is the substrate injection/storage/mixing equipment thoroughly decontaminated?	Yes No
Health and Safety		
3.	List any safety violations and corrective actions taken.	

Appendix B
Submittal Register

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Submittal Register – Groundwater Remedial Action, IRP Site 1, Former Marine Corps Air Station El Toro, California

Description Item Submitted	Contractor Dates		Approving Authority Dates					Date Received from Approving Authority	Remarks
	Date Submitted	Approval Needed By	Date Received from Contractor	Date Forwarded to Other Reviewer	Date Received from Other Reviewer	Date of Action	Date Mailed to Contractor		
Site Health and Safety Plan									
Interim Monitoring Plan									
Waste Management Plan									
Data Management Plan									
Field Change Requirements									
Field Change Notices									
Cut-Sheets for Bioremediation Substrates									
Drilling/Well Installation SOPs/Specifications									
Waste Shipping Documents									

Submittal Register – Groundwater Remedial Action, IRP Site 2, Former Marine Corps Air Station El Toro, California

Description Item Submitted	Contractor Dates		Approving Authority Dates					Date Received from Approving Authority	Remarks
	Date Submitted	Approval Needed By	Date Received from Contractor	Date Forwarded to Other Reviewer	Date Received from Other Reviewer	Date of Action	Date Mailed to Contractor		
Site Health and Safety Plan									
Interim Monitoring Plan									
Waste Management Plan									
Data Management Plan									
Field Change Requirements									
Field Change Notices									
Drilling/Well Installation SOPs/Specifications									
Waste Shipping Documents									