

AZ HWMA PERMIT
EPA ID NO. AZD 980 814 479
UNIVERSAL PROPULSION COMPANY

PERMIT ATTACHMENT H
CASOC – APPROVED WORKPLANS AND REPORTS
FINAL PERMIT Revised 12/21/2011

Exhibit H-2

Corrective Measures Study Workplan, December 2011

Changes To Corrective Measures Study Workplan

The following changes have been made to the attached Corrective Measures Study Workplan:

1. Page 3-1, Section 3.0, CMS Objectives, Groundwater:

a. The CMSWP is amended with the addition of the following bullet:

- *Corrective measures will achieve the site-wide groundwater clean up goal within 30 years.*

b. The CMSWP is amended with the third bullet modified as follows:

From:

- *To the maximum extent practicable, reduce or eliminate further releases that might pose a threat to human health and the environment.*

To:

- *Control the source(s) of release(s) so as to reduce or eliminate, to the maximum extent practicable, further releases that might pose a threat to human health and the environment.*

2. Page 4-1, Section 4.1, General Approach:

The CMSWP is amended with the addition of the following paragraph:

The Corrective Measures Study Report (CMSR) will include, for every technology passing the screening process, an initial determination of areas or volumes of media to which the general response actions will be applied, provide a conceptual plan that details how the contaminated media will be handled and treated, provide detailed documentation of how the potential remedy will comply with each of the evaluation criteria and include source control work, if practicable. Each alternative may require a separate conceptual design in order to compare against the evaluation criteria.

3. Page 4-1, Section 4.2, Soil Remedial Technologies:

The CMSWP is amended with the addition of the following sentences:

The CMSR will include for each technology utilizing soil amendments and which pass the screening process, a site specific discussion regarding how the delivery of amendments to the subsurface was evaluated. Included in the discussion will be an

evaluation of perchlorate mobilization from the soil to groundwater.

For the technologies utilizing biological reduction and which pass the screening process, the CMSR will include a discussion regarding how upon implementation of the alternative it will be determined that biological activity is responsible for remediation as opposed to soil flushing.

4. Page 4.3, Section 4.3, Groundwater Remedial Technologies:

The CMSWP is amended with the addition of the following sentences:

The CMSR will include an evaluation of water disposal options. For any waste disposal option passing the screening process, the evaluation will include the rationale for estimating influent concentrations and flow rates for all ex situ technologies.

The CMSR will include an evaluation of how groundwater amendments will be distributed into groundwater for all in-situ corrective measures that pass the screening process. The CMSR will include in the evaluation an assessment of the potential transport of amendments into nearby domestic wells.

5. Page 4-4, Section 4.3.3.1, Extraction:

The CMSWP is amended with the addition of the following sentences:

A source control corrective alternative that extracts contaminated groundwater in close proximity to Waterbore, New Burn, and C-Complex will be evaluated, if practicable, and details of the evaluation presented in the CMSR. Source control will be a component of most corrective measures. The CMSR will include a discussion regarding the rationale for estimating the volume of contaminated water requiring extraction, the estimated remediation time, and a conceptual design of the treatment system if the alternative passes the screening process.

A plume remediation alternative will be evaluated as a corrective measure, if practicable, and details of the proposed evaluation process presented in the CMSR. The alternative will include extraction wells throughout the plume area and will remediate all groundwater above the remedial goal in a reasonable time. The CMSR will detail the rationale for the groundwater extraction rates and estimates for the remediation time.

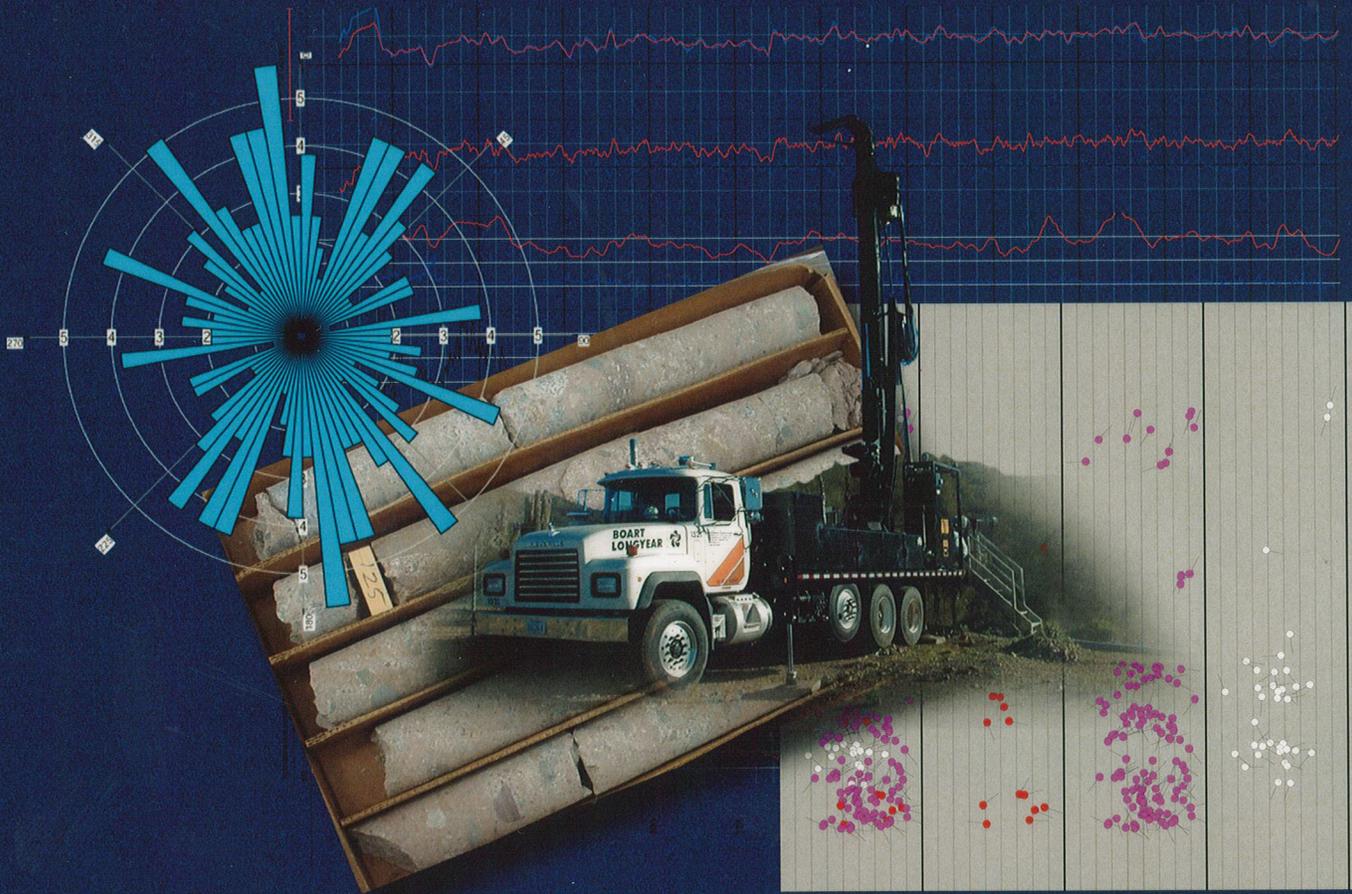
6. Page 4-5, Section 4.3.3.4, Monitored Natural Attenuation:

The CMSWP is amended with the addition of the following sentences:

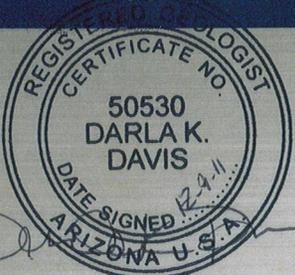
The CMSR will discuss or reference a document such as Monitored Natural Attenuation of Inorganics in Groundwater Volume 1, Technical Basis for Assessment, October 2007, that describes the MNA evaluation, including the site specific data used in the analysis. The CMSR evaluation will discuss source control and long term monitoring which are fundamental components of a MNA remedy (Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action and Underground Storage Sites, April 1999). The CMSR will discuss the establishment of time frames for the MNA evaluation, which must be capable of achieving remedial goals within a time frame that is reasonable compared to other alternatives.

Corrective Measures Study Work Plan

Universal Propulsion Co. Inc.



December 2011



EXPIRES 3/31/2013



Universal Propulsion Company, Inc.

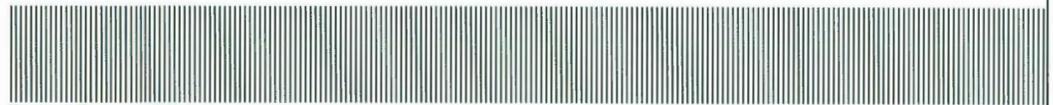
25401 N. Central Avenue • Phoenix, AZ 85085-2837

Corrective Measures Study Work Plan

December 2011



EXPIRES 3/31/2013



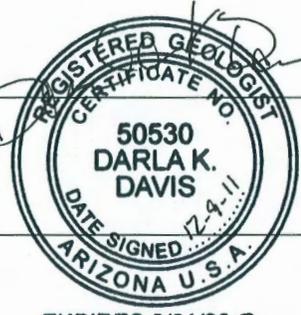
Report Prepared By:

ARCADIS U.S., Inc.

4646 E. Van Buren Street
Suite 400
Phoenix, AZ 85008-6945

3994003





Contents

1. Introduction	1-1
1.1. Purpose.....	1-1
1.2. CMS Work Plan Organization.....	1-1
2. Site Background	2-1
2.1. Location.....	2-1
2.2. Former Operations.....	2-1
2.3. Previous Investigations.....	2-1
2.3.1. Soil Characterization.....	2-2
2.3.1.1. Remedial Goals in Soil.....	2-2
2.3.1.2. Source Delineation - Soil.....	2-2
2.3.2. Soil Gas Characterization.....	2-2
2.3.2.1. Remedial Goals in Soil Gas.....	2-3
2.3.3. Groundwater Characterization.....	2-3
2.3.3.1. Remedial Goals in Groundwater.....	2-3
2.3.3.2. Source Delineation - Groundwater.....	2-4
3. CMS Objectives	3-1
4. CMS Approach	4-1
4.1. General Approach.....	4-1
4.2. Soil Remedial Technologies.....	4-1
4.2.1. No Action.....	4-1
4.2.2. Biological Remedial Technologies.....	4-1
4.2.3. Physical Remedial Technologies.....	4-2
4.2.3.1. Excavation.....	4-2
4.2.3.2. Capping.....	4-2
4.2.3.3. Soil Flushing.....	4-2
4.2.3.4. In-Situ Solidification/Stabilization.....	4-2
4.2.4. Chemical Remedial Technologies.....	4-2
4.2.4.1. In-situ Chemical Reduction.....	4-2
4.2.5. Institutional Controls.....	4-3
4.2.5.1. Deed Restrictions.....	4-3
4.3. Groundwater Remedial Technologies.....	4-3
4.3.1. No Action.....	4-3
4.3.2. Biological Remedial Technologies.....	4-3
4.3.2.1. In-Situ Biological Reduction.....	4-3
4.3.2.2. Ex-Situ Biological Reduction.....	4-3
4.3.2.3. In-Situ Reactive Barrier.....	4-4
4.3.3. Physical Remedial Technologies.....	4-4
4.3.3.1. Extraction.....	4-4
4.3.3.2. In-Situ Barrier.....	4-4
4.3.3.3. Hydraulic Control.....	4-4

4.3.3.4.	Monitored Natural Attenuation.....	4-5
4.3.4.	Chemical Remedial Technologies.....	4-5
4.3.4.1.	In-Situ Reactive Barrier	4-5
4.3.4.2.	Ex-Situ Reverse Osmosis	4-5
4.3.4.3.	Ex-Situ Ion Exchange	4-5
4.4.	Remedial Technology Screening.....	4-6
4.5.	Corrective Measures Alternatives Identification.....	4-7
4.6.	Evaluation Criteria.....	4-7
4.6.1.	Achievement of CMS Objectives.....	4-7
4.6.2.	Long Term Reliability and Effectiveness	4-7
4.6.3.	Reduction of Toxicity, Mobility and Volume	4-8
4.6.4.	Short Term Effectiveness	4-8
4.6.5.	Implementability	4-8
4.6.6.	Cost	4-9
4.7.	Remedy Selection Process.....	4-10
4.7.1.	Ranking of Corrective Measures Alternatives.....	4-10
4.7.2.	Remedy Selection	4-10
5. Data and Information Sources		5-1
5.1.	Existing Remedial Investigation Data	5-1
5.2.	Literature Data	5-1
5.3.	Data Gaps and Additional Data Gathering	5-2
6. Reporting Format		6-1
7. Schedule		7-1
8. References		8-1

Figures

1. Site Location Map
2. Site Operational Areas
3. Soil Source Areas
4. Groundwater Monitoring Network
5. Perchlorate Concentrations in Groundwater Above Remedial Goal

Appendices

- A. Schedule

1. Introduction

This Corrective Measures Study (CMS) Work Plan has been developed in accordance with Part IV, Conditions I.1 and I.2 of the Arizona Hazardous Waste Management Act (AZ HWMA) Permit for the former Universal Propulsion Company, Inc. (UPCO) facility (Site) in Phoenix, Arizona (Facility ID Number AZD 980 814 479). The CMS Work Plan outlines the objectives, approach, evaluation criteria, and schedule for conducting CMS activities for the Site.

1.1. Purpose

The purpose of the CMS Work Plan is to present the methodology by which UPCO will evaluate and select corrective measures alternatives to address contaminant of concern (COC) impacts in soil and groundwater at the Site, as identified by the remedial investigation (RI) activities and summarized in the June 2011 Final RI Report (ARCADIS, 2011). The CMS will screen potential remedial technologies that can address the COC impacts at the Site, assess the various possible alternatives for implementing corrective measures, and recommend the most appropriate corrective measure alternative(s) to be implemented at the site. This will be supported by evaluating data collected during the RI process, literature data, and supplemental data (as necessary) collected during CMS activities.

1.2. CMS Work Plan Organization

This document has been prepared in accordance with Part IV, Conditions I.1 and I.2 of the facility's AZ HWMA Permit, the State of Arizona Administrative Code (A.C.C.), Title 18, Chapter 8, Article 2, R18-8-260 et. seq., and the Arizona Hazardous Waste Management Act, A.R.S. §49-921 et.seq. This work plan includes the following sections:

- Section 1 - Introduction
- Section 2 – Site Background.
- Section 3 - Objectives of the CMS.
- Section 4 - CMS Approach (including corrective measures technology identification and methodology for remedy selection)
- Section 5 – Data Sources

- Section 6 – CMS Report Outline
- Section 7 – CMS Schedule
- Section 8 – References

2. Site Background

2.1. Location

The former UPCO facility is located at 25401 North Central Avenue in Phoenix, Arizona, near the intersection of Central Avenue and Happy Valley Road (Figure 1). The site is within the southeast quarter, Section 5, Township 4 North, Range 3 East of the Union Hills 7.5' United States Geologic Survey (USGS) quadrangle. The former UPCO facility was situated on a parcel of land leased from the State of Arizona and was initially constructed in 1972. The western and southern boundaries of the property are undeveloped land owned by the State of Arizona. The eastern boundary is owned by the Bureau of Land Management (BLM). Residential properties are to the north along Yearling Road. The former operational areas of the facility are surrounded by a security fence and primary access is limited to a gate along Happy Valley Road.

2.2. Former Operations

The facility consisted of various manufacturing, storage, and administrative buildings/structures which were separated into seven operational areas. These areas of the site are illustrated on Figure 2 and include: A-Complex, B-Complex, C-Complex, D-Complex, E-Complex (Storage Magazine Area), F-Complex, and the Open Burn Unit (New Burn Area).

UPCO, a Delaware corporation, is the successor to the original Universal Propulsion Co., a California Corporation, incorporated in 1959. UPCO began operations at the Arizona facility in 1972. UPCO became part of Goodrich Corporation in 1998. The UPCO operations were transferred to a facility in Fairfield, California in the fourth quarter of 2009. Demolition of the UPCO facility occurred throughout 2009 and was completed in January 2010.

2.3. Previous Investigations

UPCO conducted a comprehensive series of soil, soil gas and groundwater investigations to assess the nature, magnitude, and extent of potential releases associated with historical operations at the Site. Contaminants were detected in soil, soil gas and groundwater at concentrations above characterization targets, requiring further evaluation and establishment of remedial goals.

2.3.1. Soil Characterization

2.3.1.1. Remedial Goals in Soil

Remedial goals in soil were established based on Arizona soil remediation level (SRLs) or groundwater protection levels (GPLs), whichever was more stringent. Arizona Residential SRLs have been established for arsenic, lead, and perchlorate concentrations in soil that are protective of direct contact with potential human receptors in a residential scenario. ADEQ has also developed minimum groundwater protection levels (GPLs) for arsenic and lead to be protective of migration to groundwater, and potential exposure to human receptors via drinking water ingestion. ADEQ has not developed a minimum GPL for perchlorate; however, due to perchlorate's solubility and mobility and potential for migration to groundwater, a site-specific GPL was developed for perchlorate using a batch test leaching method (BTLM) model, approved by ADEQ.

The minimum GPL for arsenic and lead is 290 mg/kg, which is less stringent for arsenic but more stringent than the SRL for lead. Therefore, the Arizona residential SRL of 10 mg/kg for arsenic and the minimum GPL of 290 mg/kg for lead have been identified as remedial goals in soil at the Site. The site-specific GPL calculated for the UPCO facility for perchlorate in soil is 16 mg/kg. Since this concentration is more stringent than the Arizona residential SRL of 55 mg/kg, the remedial goal for perchlorate in soil at the Site is the GPL of 16 mg/kg.

2.3.1.2. Source Delineation - Soil

Three COPCs have been identified in soil at concentrations above the remedial goals: perchlorate, lead and arsenic. The highest concentrations of perchlorate in soil at the former UPCO facility, and the deepest vertical extent of elevated perchlorate concentrations in soil (to 175 feet bgs), were observed in the Waterbore Area. There were also some elevated perchlorate concentrations in soil detected in the C-Complex and the New Burn Area, at depths ranging from 0 to 20 feet bgs. Lead concentrations in soil appear to be attributed to historic burning of waste propellants in the former open burning areas: Old Burn Area and New Burn Area. The elevated lead detected in surface soil at the New Burn Area was removed during the OBU closure activities. Observed arsenic concentrations in soil are considered consistent with naturally occurring conditions. Figure 3 presents the source areas at the Site where COCs are present in soil at concentrations above the remedial goals.

2.3.2. Soil Gas Characterization

VOCs were detected in soil gas samples collected in B-Complex, C-Complex, F-Complex, and Old Burn Area. The suspected source of the VOC detections is historic solvent and adhesive use in these areas. 1,1-DCE, acetone and MEK have been identified

as the COPCs in soil vapor based on frequency of detection, magnitude of concentration, historic usage, and detection in groundwater samples. The largest VOC impacts to soil vapor were observed in the B-Complex. The VOC concentrations detected in B-Complex do not appear to be impacting groundwater above characterization targets, based on groundwater monitoring data obtained at wells in the vicinity of the B-Complex (MW-1, MW-2, MW-6, MW-7, MW-10, MW-12, and PW-1) as well as the grab groundwater sample collected beneath the suspected source area in B-Complex, SWMU 5.

2.3.2.1. Remedial Goals in Soil Gas

There are two potential migration pathways for the COPCs in soil gas that may pose an exposure risk to human receptors. One pathway involves vertical migration downward, dissolution in groundwater, and ingestion; while the other involves vertical migration upward, vapor intrusion into buildings (current or future) and inhalation. Based on the vertical profile of VOC concentrations in soil gas at the suspected source area in B-Complex (collected at SVMW-1), the majority of the VOC mass is approximately 100 feet bgs and is not impacting the groundwater which is located approximately 210 feet bgs.

Potential indoor air exposure risks due to VOCs in soil gas at the Site were evaluated using the Johnson & Ettinger (J&E) Vapor Intrusion Model. Using the EPA's on-line J&E screening tool, soil gas concentrations protective of indoor air were calculated to be 26,900 ppbv for 1,1-DCE, 65,440 ppbv for acetone, and 194,200 ppbv for MEK, assuming a depth to contamination of 10 feet bgs and using default parameters for building design. These concentrations have been established as the remedial goals for 1,1-DCE, acetone, and MEK in soil gas.

VOCs have not been detected in soil gas at concentrations above the remedial goals. Therefore, corrective measures are not required to address VOCs detected in soil gas at the site. This CMS work plan does not include an evaluation of soil gas remedial alternatives. VOCs in soil gas will continue to be monitored at SVMW-1 to assess if migration to groundwater has the potential to become a pathway of concern in the future.

2.3.3. Groundwater Characterization

2.3.3.1. Remedial Goals in Groundwater

The Permit for the Site specified the Arizona Department of Health Services (ADHS) health based guidance level (HBGL) of 14 µg/L for perchlorate in groundwater was protective of ingestion in a residential exposure scenario. Therefore, the HBGL of 14 µg/L has subsequently been established as the remedial goal for perchlorate in groundwater at the Site.

The remedial goal established for 1,1-DCE in groundwater at the Site is the aquifer water quality standard (AWQS) of 7 µg/L.

2.3.3.2. Source Delineation - Groundwater

Perchlorate and 1,1-DCE are the two COCs identified in groundwater. In 2004, groundwater sampling at the production well, PW-1, detected 1,1-DCE at a concentration above the remedial goal of 7 µg/L. 1,1-DCE has not been detected above the laboratory reporting limit in the other site monitoring wells. The concentration of 1,1-DCE in PW-1 has not been detected above the remedial goal since 2004.

Perchlorate is currently detected in groundwater at concentrations above the remedial goal of 14 µg/L in samples collected at monitor wells MW-1, MW-2, MW-5, MW-6, and MW-19. Elevated perchlorate concentrations in groundwater at MW-19 are attributed to historical waterbore operations. Elevated perchlorate concentrations at MW-1 and MW-2 may be attributed to historical waterbore operations, propellant production in the C-Complex, waste propellant burning in the New Burn Area, and/or a combination of these sources. The elevated perchlorate concentrations in MW-6 are considered to be potentially attributed to historic release(s) at F-Complex via surface drainage and infiltration from a wash on the west side of the facility.

Figure 4 shows the monitoring network established during the RI activities and Figure 5 shows the inferred extent of perchlorate concentrations in groundwater above the remedial goal.

3. CMS Objectives

The goal of the CMS is to identify corrective measures that will effectively mitigate impacts to soil and groundwater in a manner that provides short-term and long-term protection of human health and the environment to the extent practicable. The CMS objectives are intended to be specific to the affected media (i.e., soil and groundwater), but sufficiently broad so as not to overly restrict the potential remedial technology available. The CMS objectives are based on requirements listed in the AZ HWMA facility permit and also consider guidance provided in the EPA's *RCRA Corrective Action Plan - Final, May 1994 (EPA 520/R/94/004)*.

The CMS Objectives are as follows:

Soil

- Reduce or eliminate direct contact by a potential receptor (including ingestion, inhalation, or dermal absorption), or threat of direct contact, with COCs in surface or subsurface soils.
- Reduce or eliminate the potential for COCs in surface or subsurface soils to migrate to groundwater.
- To the maximum extent practicable, reduce or eliminate further releases that might pose a threat to human health and the environment
- In accordance with Part IV, Condition C.10 of the Permit, achieve a clean up level for soils that is in accordance with the Arizona Soil Remediation Standards rule (A.A.C. Title 18, Chapter 7, Article 2). A site-specific GPL for perchlorate of sixteen (16) mg/kg has been established.
- Meet applicable waste management requirements.

Groundwater

- Minimize, stabilize or eliminate further migration of the contaminant plume.
- Prevent migration of perchlorate in groundwater to any active private domestic well in the area bounded by Central Avenue, 7th Street, Yearling Road, and Jomax Road at concentrations above 14 ug/L.

- To the maximum extent practicable, reduce or eliminate further releases that might pose a threat to human health and the environment
- In accordance with Part IV, Condition C.9 of the Permit, achieve a sitewide groundwater clean up goal or remedial action objective for perchlorate of fourteen (14) ug/L.
- Meet applicable waste management requirements.

4. CMS Approach

4.1. General Approach

The CMS is designed to evaluate and select corrective measures alternatives to address COC impacts in soil and groundwater at the Site. This is accomplished by identifying potential soil and groundwater remedial technologies that can be implemented at the Site. These technologies are initially screened to assess their technical feasibility for implementation at the site. Corrective measures alternatives are then developed, using one or more of the technologies identified by the screening process, for further evaluation. The corrective measures alternatives are evaluated and ranked against criteria established by the Permit, including ability to meet CMS objectives, implementability, short- and long-term effectiveness, ability to reduce risks to human health and the environment, and cost. The selected corrective measures alternative for soil and groundwater will be the alternative with the highest ranking that can accomplish the CMS objectives. The following sections outline the CMS approach in more detail. The EPA's *RCRA Corrective Action Plan - Final, May 1994 (EPA 520/R/94/004)* was referenced to guide the CMS approach..

4.2. Soil Remedial Technologies

The following sections outline remedial technologies that will be evaluated during the CMS to address COC impacts to soil at the Site. The technologies are grouped based on their primary treatment mechanism (i.e., biological, physical and chemical). A no action scenario and institutional controls will also be evaluated.

4.2.1. No Action

The no-action alternative will be evaluated to establish a baseline for the short-term and long-term comparison. Under this alternative, no active corrective measures would be employed.

4.2.2. Biological Remedial Technologies

In-situ bioremediation (ISB) is a controlled biological process in which naturally occurring perchlorate-reducing microorganisms convert perchlorate to chloride and oxygen. Bioremediation reduces perchlorate via enzymatic degradation by select species of bacteria under anaerobic conditions.

4.2.3. Physical Remedial Technologies

4.2.3.1. Excavation

Soil excavation and off-site disposal can be an effective means of source and residual contaminant removal and is most notably applied as a removal measure for surface and shallow soil impacts. Soil excavation typically involves the use of standard earth moving equipment such as track hoes, dozers and loaders.

4.2.3.2. Capping

Containment technologies, such as capping, can control potential hazards by eliminating routes of exposure and potentially reducing constituent migration through isolation and elimination of surface-water infiltration.

4.2.3.3. Soil Flushing

In-situ flushing is defined as the injection or infiltration of an aqueous solution into a zone of contaminated soil, followed by downgradient extraction of groundwater and elutriate (flushing solution mixed with the contaminants) and aboveground treatment and discharge or re-injection. (GWTRAC, 1998)

4.2.3.4. In-Situ Solidification/Stabilization

In-situ solidification/stabilization (also referred to as “deep soil mixing” or “in-situ enhanced soil mixing”) technology is used to immobilize contaminants by encapsulating or immobilizing contaminants within the host medium instead of removing them through chemical or physical treatment. These techniques represent permanent remedies.

4.2.4. Chemical Remedial Technologies

4.2.4.1. In-situ Chemical Reduction

In-situ chemical reduction (ISCR) is an aggressive technology that involves the injection of chemical reductants that destroy organic compounds in groundwater. Complete reduction of compounds results in their breakdown into nontoxic compounds such as sulfur-oxygen compounds and chloride anions. This technology can significantly increase the mass transfer between the residual contaminated soil and groundwater, subsequently destroying the COC mass in a shorter period of time. Several factors affect the performance of this technology, including reductant delivery to the subsurface, reductant type, dose of reductant, COC type and concentration, and non-COC reductant demand.

The commonly used reductants include zero valent metals (e.g., iron and zinc), iron minerals (e.g., green rust, pyrite, magnetite, and glauconite), polysulfides, dithionite, bimetallic materials, and proprietary materials. In-situ chemical reduction exhibits several

reductive processes that include hydrogenolysis, β -elimination, hydrogenation, α -elimination, and electron transfer. The most common ways to implement ISCR are with permeable reactive barriers and by the direct injection of reductants into the subsurface.

4.2.5. Institutional Controls

4.2.5.1. Deed Restrictions

Deed restrictions are a form of institutional control that utilizes legal mechanisms to control future land use. Deed restrictions require cooperation with local government agencies and strict enforcement in order to effectively control future development and access. The effectiveness of land use deed restrictions can be increased when used in conjunction with physical barriers that limit access to impacted areas, if needed.

4.3. Groundwater Remedial Technologies

The following sections outline remedial technologies that will be evaluated during the CMS to address perchlorate impacts to groundwater at the Site. Similar to the soil remedial technologies, the groundwater technologies are grouped based on their primary treatment mechanism (i.e., biological, physical and chemical). A no action scenario will also be evaluated.

4.3.1. No Action

The no-action alternative will be evaluated to establish a baseline for comparison. Under this alternative, no response action of any kind would be employed.

4.3.2. Biological Remedial Technologies

4.3.2.1. In-Situ Biological Reduction

Biological reduction relies on creating reducing conditions by adding a soluble organic substrate (e.g., alcohols, sugars, edible oils or organic acids) and, as necessary, nutrients (nitrogen and phosphorus) to the perchlorate-impacted groundwater. Perchlorate-reducing bacteria are considered ubiquitous in the environment. The organic substrate first consumes oxygen and nitrate/nitrite. Once the oxidation/reduction potential (ORP) is reduced to the lower end of the denitrifying range, perchlorate becomes a predominant electron acceptor. As groundwater passes through the system, the microorganisms derive energy from the oxidation of the organic substrate, reducing the perchlorate to chloride and carbon dioxide (Van Den Berg and Baugh).

4.3.2.2. Ex-Situ Biological Reduction

Following the same biological reduction mechanisms described in the previous section, ex-situ biological reduction involves the treatment of groundwater extracted from the subsurface within designed treatment vessels. A variety of ex-situ biological reactors,

including continuous-flow stirred tank reactors (CSTRs), packed-bed reactors (PBRs), and fluidized-bed reactors (FBRs), will be considered for ex situ bioremediation of perchlorate in groundwater (ITRC, 2005).

4.3.2.3. In-Situ Reactive Barrier

A permeable reactive barrier (PRB) is an in situ method for remediating contaminated ground water that combines a passive treatment zone with subsurface fluid flow management. Treatment media could include biological perchlorate reducing agents. The contaminants are concentrated and either degraded or retained in the barrier material, which may need to be replaced periodically.

PRBs can be installed as permanent or semi-permanent units. The most commonly used PRB configuration is that of a continuous trench in which the treatment material is backfilled. The trench is perpendicular to and intersects the ground-water plume. Another frequently used configuration is the funnel and gate, in which low-permeability walls (the funnel) direct the ground-water plume toward a permeable treatment zone (the gate). Some gates are in situ reactors that are readily accessible to facilitate the removal and replacement of reactive media. These PRBs use collection trenches, funnels, or complete containment to capture the plume and pass the ground water, by gravity or hydraulic head, through a vessel containing either a single treatment medium or sequential media. In circumstances where in situ treatment is found to be impracticable, reactive vessels have been located above ground (USEPA, 2011).

4.3.3. Physical Remedial Technologies

4.3.3.1. Extraction

Extraction of groundwater involves removal of dissolved contaminants from the subsurface, and containment of contaminated groundwater to prevent migration. Extraction could be coupled with a chemical or biological treatment alternative.

4.3.3.2. In-Situ Barrier

An in-situ barrier is a physical control of blocking flow of impacted groundwater with an impermeable barrier.

4.3.3.3. Hydraulic Control

Hydraulic control technologies may reduce mobility, but may not necessarily reduce the toxicity or volume of site-related constituents in groundwater. These technologies typically require treatment of the recovered groundwater and may involve reinjection of treated water.

4.3.3.4. Monitored Natural Attenuation

Monitored natural attenuation (MNA) is a technology that relies on natural attenuative processes, along with monitoring to achieve the site-specific corrective action objectives. Monitored natural attenuation includes physical, chemical, and biological processes that act to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. These processes include dispersion, dilution, sorption, volatilization, and chemical or biological stabilization, transformation or destruction of contaminants. The use of natural attenuation requires demonstration through sampling and evaluation that natural processes will reduce concentrations to acceptable levels in accordance with remedial objectives..

4.3.4. Chemical Remedial Technologies

4.3.4.1. In-Situ Reactive Barrier

A permeable reactive barrier (PRB) is an in situ technology used to treat perchlorate-contaminated groundwater. Some of the commonly used reactive materials for barriers include soybean and other edible oils, woodchips, pecan shells, cotton seed, chitin, limestone, and other composting materials. Many of these materials can provide both electron donors and the necessary nutrients for microbial growth. Soluble electron donors such as lactate, acetate, and citrate may be added to the barrier materials to further stimulate biodegradation of perchlorate to chloride and oxygen (USEPA, 2005).

4.3.4.2. Ex-Situ Reverse Osmosis

Reverse osmosis is a physical separation method based on the principle of osmosis. In this technology, high pressure is applied to reverse the osmosis process and force water molecules to pass through the semi-permeable membrane out of the perchlorate-contaminated water. As a result, two channels of water are formed, one is treated water from the freshwater side of the system and the other is concentrate containing perchlorate, which is subject to further treatment prior to disposal (USEPA, 2005).

4.3.4.3. Ex-Situ Ion Exchange

Perchlorate and other anionic contaminants in groundwater can be effectively removed by anion exchange, a process where contaminant anions are exchanged and replaced by an innocuous anion, typically chloride. Ion exchange is an effective method for many groundwater treatment applications due to its efficiency in removing contaminants present in varying concentrations. Key parameters that determine the efficiency of an ion exchange process are treatment ratio and the volume of regeneration waste generated. Treatment ratio refers to the volume of feed water that can be treated before breakthrough of the contaminant(s) is obtained. Regeneration waste volume refers to the volume of waste generated by the ion exchange process while regenerating the ion exchange resin

saturated with contaminants. An effective ion exchange process is one that achieves high treatment ratios while producing low regeneration waste volume (Van Den Berg and Baugh).

4.4. Remedial Technology Screening

Site characteristics and other information/data obtained during the RI will be used to conduct an initial technology screening. Those technologies that cannot be effectively implemented will be removed from further consideration as part of a potential corrective measures alternative. This initial screening analysis will evaluate the feasibility of each technology as it relates to the site characteristics, specific contaminant types and concentrations (effectiveness), implementability, and past performance at similar sites.

The implementability screening will encompass both the technical and administrative feasibility of implementing the technology processes listed in Section 4.3. The technical feasibility will assess information obtained during the remedial investigation regarding contaminant types and concentrations and Site characteristics (e.g., Site geology and hydrogeology) to screen out options that cannot be effectively implemented at the Site. Site characteristics that could affect the implementability of a technology option include, but are not limited to, depth to impervious formations, depth to groundwater, presence of bedrock fracturing, etc. Factors that will be considered during the assessment of administrative feasibility include, but will not be limited to, the ability to obtain necessary permitting, availability of treatment, storage or disposal facilities for remediation-derived wastes, or availability of necessary equipment.

The effectiveness screening will consider the ability of each technology to reduce the estimated mass of the contaminants of concern and treat the respective volumes of impacted media to meet the corrective measures objectives. The effectiveness screening will also consider the potential impacts to human health and the environment during the construction or implementation of the technology as well as potential long-term impacts (during the period after the remedial action is complete). It will consider the ability of each technology to effectively decrease the inherent threats or risks associated with the contaminants of concern, while minimizing or preventing the generation of treatment residuals that could be harmful to human health or the environment.

The reliability screening will consider the ability of each technology to treat the contaminants at the Site, based on proven success at other sites. This will be accomplished by evaluating case studies of treatment technologies successfully implemented at sites that have similar characteristics (e.g., nature and extent of impacts, geology, and hydrogeology) to the UPCO site.

While relative cost of remedial technologies is a factor commonly used during the technology screening process, eliminating any potential remedial technologies from further consideration based on costs is not anticipated. Therefore, evaluation of relative cost will be removed from the technology screening process. However, more detailed cost analyses, as described in Section 4.6.6, will be conducted as part of the corrective measures alternatives evaluation, and will be one of the factors considered during remedy selection.

4.5. Corrective Measures Alternatives Identification

Technologies that pass the initial screening are considered potentially feasible for soil or groundwater treatment. These technologies will then be evaluated as corrective measures alternatives, either as stand-alone remedies or in tandem, to meet the CMS Objectives. While it's possible to identify and assess multiple combinations of soil and groundwater treatment technologies, the CMS will limit the number of corrective measures alternatives to be evaluated based on successful implementation at other sites with perchlorate impacts. It is anticipated that between three and five corrective measures alternatives for soil will be evaluated and between four and six corrective measures for groundwater will be evaluated. The following sections outline the criteria that will be used for the corrective measures alternatives evaluations.

4.6. Evaluation Criteria

The following criteria, as identified by Part IV, Condition J.2 of the Permit, will be used as evaluation factors during the remedy selection process.

4.6.1. Achievement of CMS Objectives

Each corrective measures alternative will be evaluated to determine their ability to achieve the CMS Objectives outlined in Section 3 of this work plan.

4.6.2. Long Term Reliability and Effectiveness

To establish the degree of certainty that the remedy will prove successful, each corrective measures alternative will be evaluated to assess the following factors over a 30-year timeframe:

- Magnitude of residual risks in terms of amounts and concentrations of waste remaining following remedy implementation, considering the persistence, toxicity, mobility and propensity to bio-accumulate of such hazardous wastes including hazardous constituents and perchlorate;

- Type and degree of long-term management required, including monitoring, operation and maintenance;
- Exposure potential of humans and environmental receptors to remaining wastes, considering potential threats to human health/environment associated with excavation, transportation, re-disposal or containment;
- Long-term reliability of the engineering and institutional controls, including uncertainties associated with land disposal of untreated wastes and residuals;
- Potential need for replacement of the remedy

4.6.3. Reduction of Toxicity, Mobility and Volume

To assess the degree to which each corrective measures alternative will reduce toxicity, mobility, or volume of hazardous wastes (including hazardous constituents and perchlorate) at the Site, the following factors will be considered:

- The treatment processes the remedy(s) employs and materials it would treat;
- Amount of hazardous wastes (including hazardous constituents and perchlorate) that would be destroyed or treated;
- The degree to which the treatment is irreversible; and
- The residuals that will remain following treatment, considering the persistence, toxicity, mobility and propensity to bio-accumulate of such hazardous wastes (including hazardous constituents and perchlorate).

4.6.4. Short Term Effectiveness

To assess the short-term effectiveness of each corrective measures alternative, the following factors will be considered:

- Magnitude of reduction of existing risks;
- Short-term risks that might be posed on the community, workers, or environment during implementation of such remedy, including potential threats to human health and the environment associated with excavation, transportation, re-disposal or containment; and
- Time until full protection is achieved.

4.6.5. Implementability

The ease or difficulty of implementing each corrective measures alternative will be assessed by considering the following types of factors:

- Degree of difficulty associated with constructing the technology;
- Expected operational reliability of the technologies;
- Need to coordinate/obtain necessary approvals and permits from other agencies;
- Availability of necessary equipment and specialists; and
- Available capacity, location of needed treatment, storage and disposal services.

4.6.6. Cost

A detailed net present-worth cost estimate of each corrective measures alternative will be prepared. The cost estimate will include an analysis of both direct (construction) and indirect (non-construction and overhead) capital costs, and operations and maintenance costs as appropriate.

The direct capital costs that will be considered include:

- Construction Costs - Costs of materials, labor, and equipment necessary to implement the alternative.
- Equipment Costs - Costs of the equipment and/or services necessary to implement the alternative; these will remain until operation is complete.
- Land and Site Development Costs - Costs associated with site or building preparation.
- Building and Service Costs - Costs for process and non-process buildings, utility connections and purchased services.
- Disposal Costs - Costs of transporting and disposing of waste material generated during remedy construction and start-up

The indirect capital costs will include:

- Engineering Expenses - Costs of administrative, design, drafting, and construction supervision.
- Legal Fees and License or Permit Costs - Administrative and technical costs to obtain licenses and permits for installation and operation.
- Startup and Shakedown Costs - Costs incurred during startup.
- Contingency Allowances - Funds to cover unforeseen circumstances.
- Shutdown Costs - Any costs necessary for termination of operation.

O&M Costs to be considered for each corrective measures alternative will include:

- Operating Labor Costs - Wages, salaries, training, overhead, and fringe benefits associated with labor needed for post-construction operations.

- Maintenance Materials and Labor Costs - Costs for labor, parts and other resources required for routine maintenance of facilities and equipment.
- Auxiliary Materials and Energy - Costs of items such as chemicals and electricity for treatment plant operations, water, sewer service, and fuel.
- Purchased Services - Sampling costs, laboratory fees, and professional fees.
- Disposal and Treatment Costs - Costs for treatment and disposal of waste material from alternative processes.
- Administrative Costs - Costs associated with administration of alternatives.
- Insurance, Taxes, and Licensing Costs - Costs such as liability and sudden accident insurance, licensing fees, or permit renewal and reporting costs.
- Maintenance Reserve and Contingency Funds - Costs of anticipated replacement or rebuilding of equipment or unanticipated operations and maintenance costs.
- Other Costs - Items that do not fit into the above categories.

The cost estimates will be developed using a combination of RSMMeans Cost Data, vendor quotations, and previous project costs associated with the RI activities.

4.7. Remedy Selection Process

4.7.1. Ranking of Corrective Measures Alternatives

In order to objectively compare the corrective measures alternatives, and assist in the selection process, a numerical matrix analysis will be conducted. In the matrix analysis, evaluation criteria will be listed as row headings and each corrective measures alternative will be listed as column headings. A separate matrix will be created for soil and groundwater corrective measures alternatives. Numerical ratings will be assigned to each alternative with respect to meeting the requirements of each of the five distinct evaluation criteria identified in Section 4.6. Ratings between 1 (lowest) and 5 (highest) will be assigned based on a relative appraisal of the degree to which each alternative can meet the criterion. The total rating for each alternative will be calculated by summing the ratings for each evaluation criteria.

4.7.2. Remedy Selection

The corrective measure alternatives in soil and groundwater will be ranked based on their total evaluation criteria scores, as discussed in the previous section. The alternatives in soil and groundwater with the highest rankings, that also meet the CMS objectives, will be recommended for implementation at the Site. The primary consideration will be the ability of the recommended alternative to protect public health, with the remaining evaluation criteria balanced to provide the most effective overall alternative, considering

reliability, performance, implementability, safety, environmental protection and cost-effectiveness. In addition to the permit, the EPA's *RCRA Corrective Action Plan - Final, May 1994 (EPA 520/R/94/004)* will be referenced to guide the remedy selection process.

5. Data and Information Sources

5.1. Existing Remedial Investigation Data

The RI activities included the collection of a variety of environmental media data, as well as geologic and hydrogeologic data, to develop a conceptual site model that defines the nature and extent of COC impacts to soil and groundwater at the Site. RI data that will be used during the corrective measures alternatives evaluation include:

- Surface and subsurface soil analytical data;
- Groundwater analytical data;
- Groundwater elevation data;
- Lithologic logs;
- Geophysical logs;
- Hydrogeophysical logs; and
- Aquifer testing data.

As discussed in the Permit, for CMS purposes, the perchlorate impacted groundwater at C-Complex and the New Burn Area will be considered similar to the perchlorate impacted groundwater at the Waterbore Area. Unless additional data is collected during the CMS activities, source area data collected from monitor wells MW-13 and MW-19, installed at the Waterbore Area, will be used to evaluate corrective measures alternatives at the C-Complex and the New Burn Area.

5.2. Literature Data

In addition to the RI data, the corrective measures alternative evaluation will utilize literature data from other sources that represent similar current and/or future conditions anticipated at the Site. These literature sources will include:

- regional geologic or hydrogeologic studies;
- regional meteorological data;

- Arizona Department of Water Resources (ADWR) data;
- data associated with the successful implementation of treatment technologies at other perchlorate-impacted sites in the western U.S.

5.3. Data Gaps and Additional Data Gathering

At this time, it is anticipated that the currently available RI data and literature data, and ongoing monitoring data collection, will be adequate to conduct the corrective measures alternatives evaluation and select the proposed soil and groundwater remedies at the Site. If during the remediation technology screening process or the corrective measures alternatives evaluation it is determined that additional data is required to appropriately evaluate and rank the alternatives, then supplemental CMS field activities will be proposed. These supplemental CMS activities may include, but not be limited to, installation of additional wells, conducting additional pump tests, or conducting pilot tests to evaluate treatment technologies. In the event data gaps are identified and additional CMS data gathering activities are needed, supplemental work plans will be submitted to ADEQ for review and approval prior to conducting the field activities.

6. Reporting Format

At the completion of the technology screening process, a CMS progress report letter will be submitted to ADEQ that outlines the results of the initial corrective measures technology screening, identification of corrective measures alternatives that will be evaluated further, and a description of proposed additional data collection activities, if necessary.

At the completion of the CMS activities, the findings and conclusions of the study will be summarized in a CMS Report. The anticipated general outline for the CMS report is as follows:

- Introduction
- Site Background
- CMS Objectives
- CMS Process
 - Technology Identification
 - Evaluation Criteria
 - Data sources
- Summary of Supplemental CMS Data (if necessary)
- Technology Screening
 - Screening Matrix
- Identification of Corrective Measures Alternatives
- Evaluation of Corrective Measures Alternatives
 - Ranking Matrix
- Remedy Selection

The Evaluation of Corrective Measures Alternatives section will include a comparison of each alternative's ability to achieve the pertinent evaluation criteria. The section will include summary tables, which allow the alternatives to be easily understood. These summary tables will highlight tradeoffs between health risks, environmental effects, and other pertinent factors.

7. Schedule

The CMS activities will be conducted in a manner that will facilitate the submittal of a draft CMS Report to ADEQ by March 15, 2012, in accordance with Part II, Condition I.1 of the Permit. It is anticipated that initial technology screening will be completed by the end of November 2011. Corrective measures alternatives identification and evaluation will occur approximately between December 2011 and February 2012. Supplemental CMS field activities, if necessary, would need to be conducted between January and February 2012 to allow adequate time for data collection, tabulation, and evaluation.

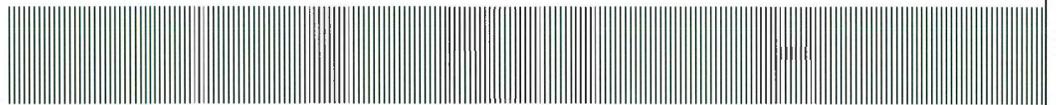
The projected schedule to complete the CMS process at the UPCO facility is included as Appendix A.

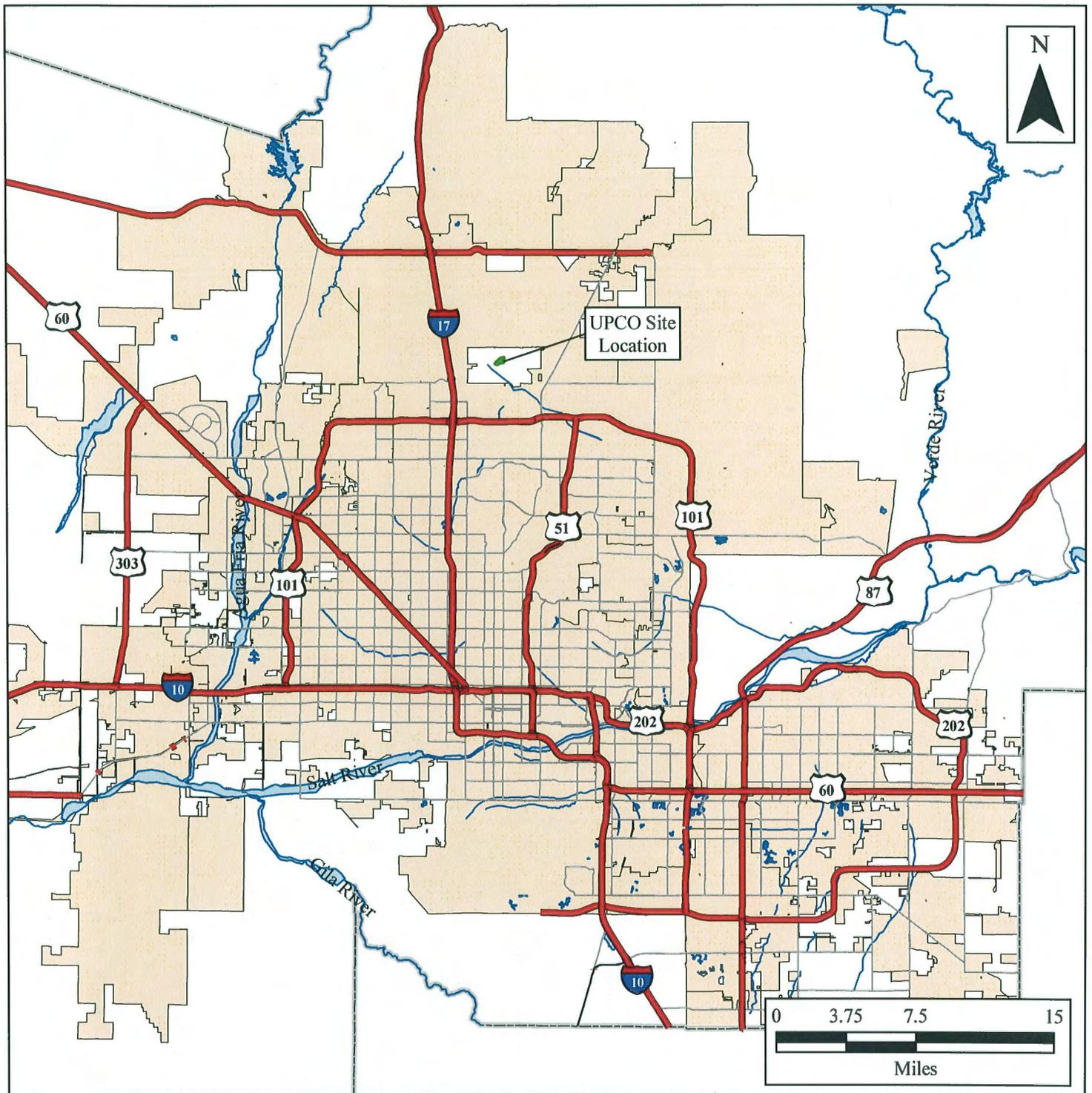
8. References

- ARCADIS. 2011. Final Remedial Investigation Report. Universal Propulsion Company, Inc. June 2011.
- Groundwater Remediation Technologies Analysis Center (GWRTAC); *Technology Status Report In Situ Flushing*; Prepared by Diane S. Roote, PG; November 1998
- Interstate Technology Regulatory Council (ITRC). 2005. Perchlorate: Overview of Issues, Status, and Remedial Options; September 2005.
- United States Environmental Protection Agency (USEPA). 2005. Perchlorate Treatment Technology Update. Federal Facilities Forum Issue Paper; EPA 542-R-05-015; May 2005.
- USEPA. 2011. Permeable Reactive Barriers, Permeable Treatment Zones, and Application of Zero-Valent Iron; U.S. EPA Contaminated Site Cleanup Information (CLU-IN); [http://www.clu-in.org/techfocus/default.focus/sec/Permeable Reactive Barriers%2C Permeable Treatment Zones%2C and Application of Zero-Valent Iron/cat/Overview/](http://www.clu-in.org/techfocus/default.focus/sec/Permeable_Reactive_Barriers%2C_Permeable_Treatment_Zones%2C_and_Application_of_Zero-Valent_Iron/cat/Overview/)
- USEPA. 1994. *RCRA Corrective Action Plan - Final, May 1994 (EPA 520/R/94/004)*
- Van Den Berg, H., and Baugh, K. Selection of Remedial Technologies for Perchlorate-Impacted Sites.

Universal Propulsion Company
Corrective Measures Study Work Plan

Figures





Legend

- Site Location
- Primary Roads
- Highways, Freeways
- Rivers
- County Boundaries
- Lakes
- City Master Planning Area Boundaries

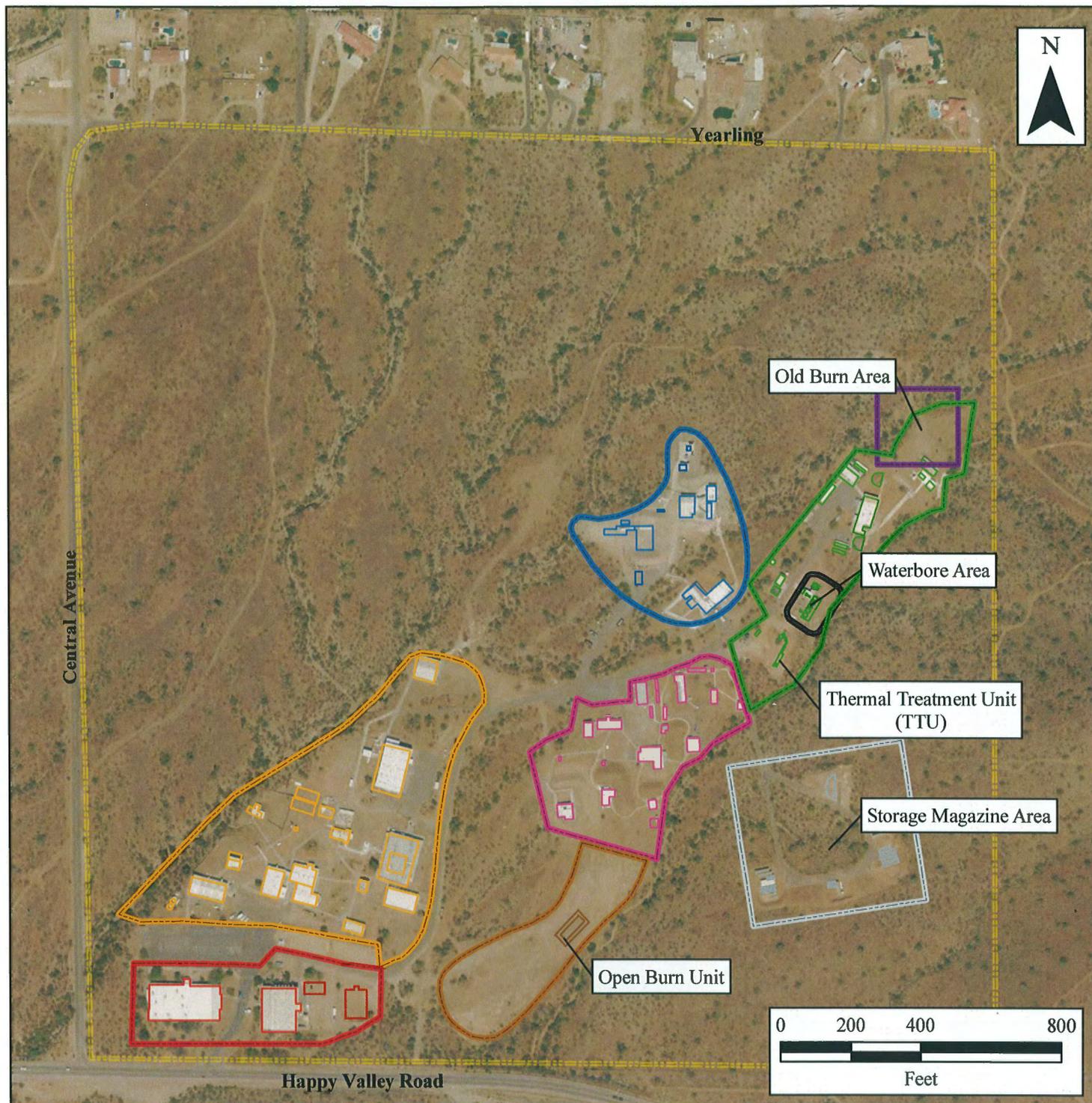


Site Location Map
Corrective Measures Study
Work Plan
Universal Propulsion Company, Inc.

Source: City boundaries from Maricopa Association of Governments, 2005.
Other data from Teletlas, Oct. 2003.

December 2011

Figure 1



Aerial Photo copyright Landiscor, Inc. 2008 all rights reserved

Legend

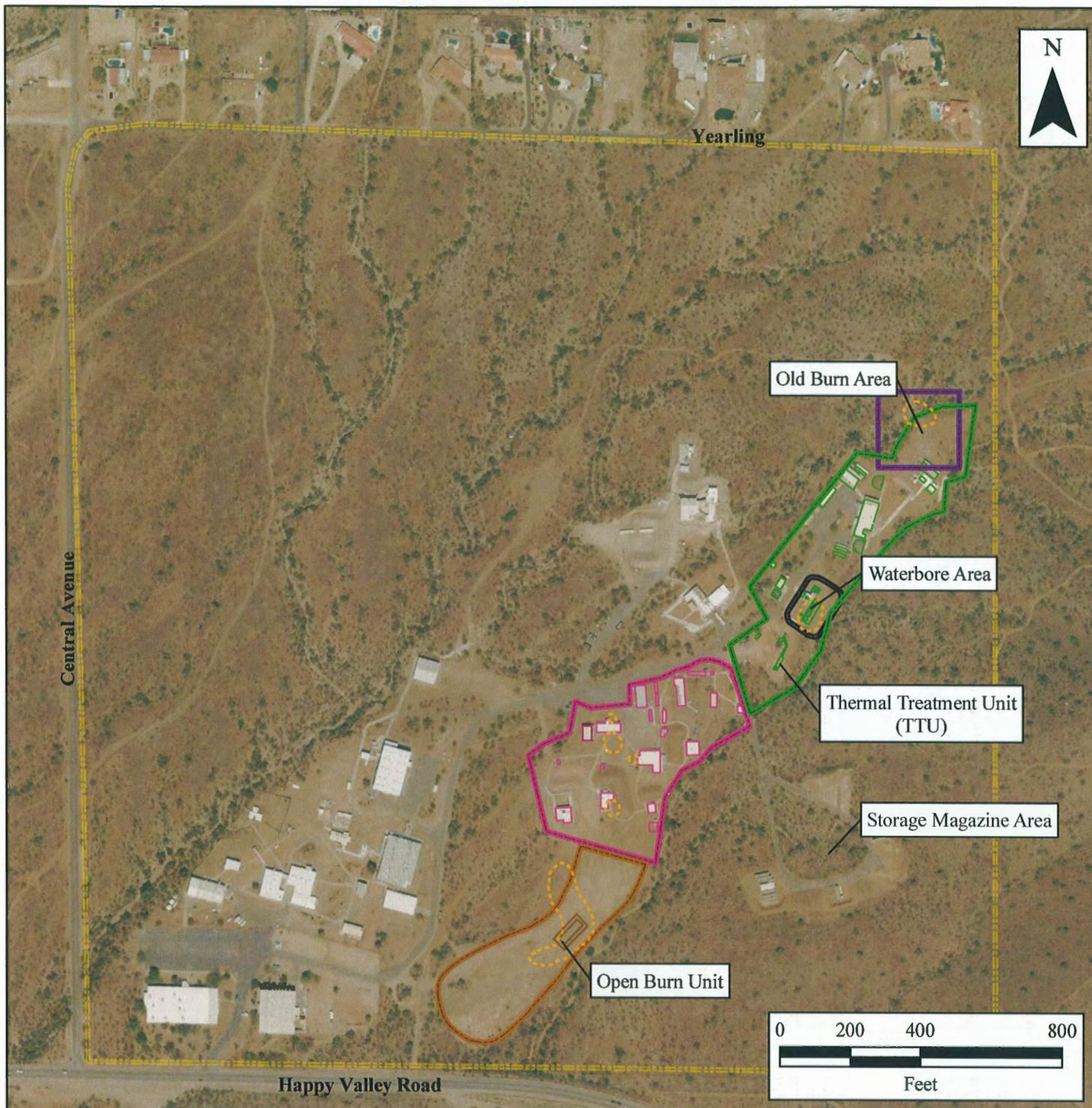
- | | |
|---|---|
|  Lease Property Boundary |  D-Complex |
|  A-Complex |  E-Complex |
|  B-Complex |  F-Complex |
|  C-Complex |  New Burn Area |



Facility Operational Areas
 Corrective Measures Study
 Work Plan
 Universal Propulsion Company, Inc.

December 2011

Figure 2



Aerial Photo copyright Landiscor, Inc. 2008 all rights reserved

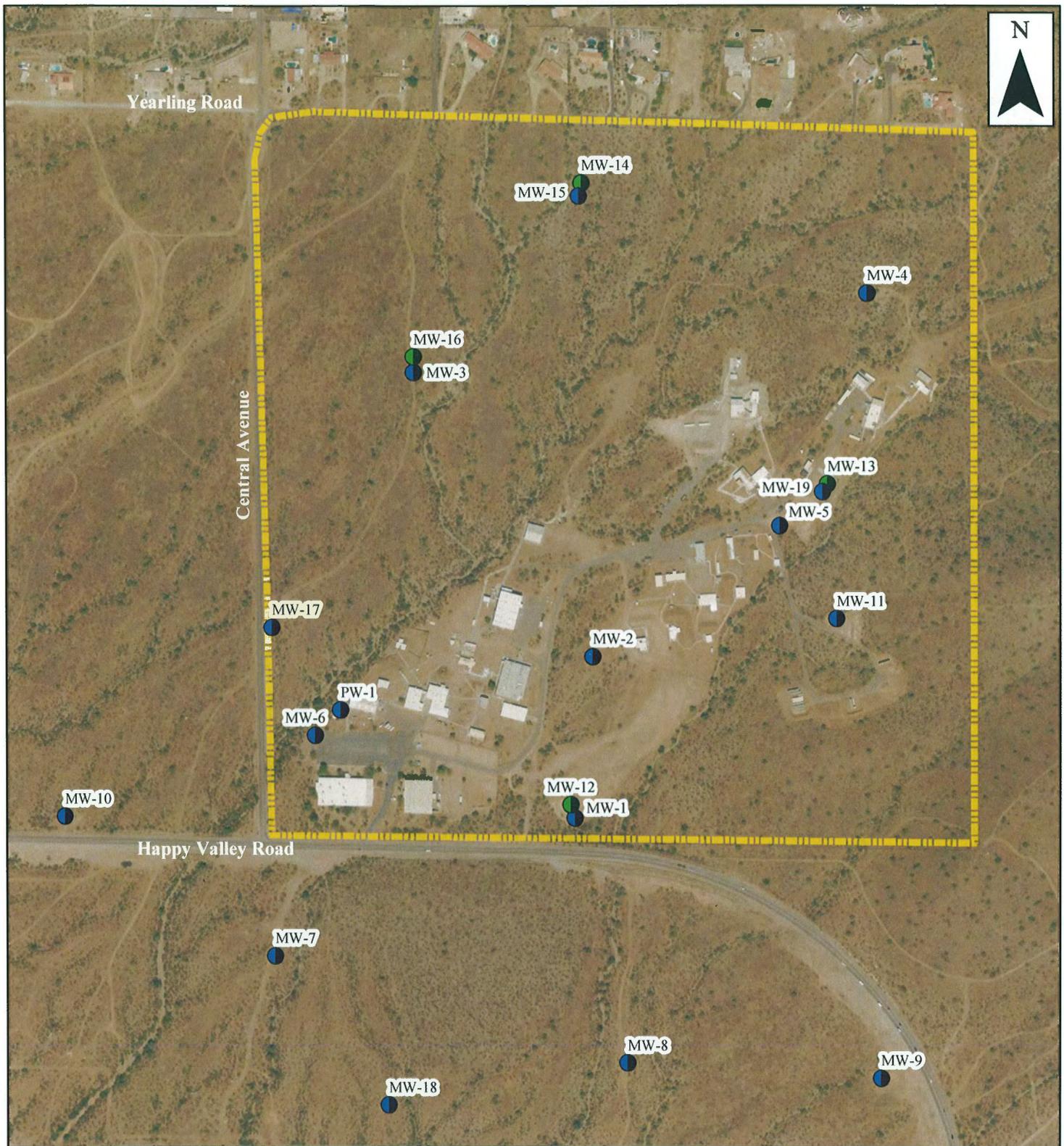
Legend

-  Lease Property Boundary
-  C-Complex
-  D-Complex
-  New Burn Area
-  Soil Source Areas



Soil Source Areas
Corrective Measures Study
Work Plan
Universal Propulsion Company, Inc.

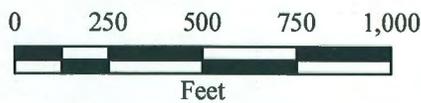
December 2011	Figure 3
---------------	-----------------



Aerial Photo copyright Landiscor, Inc. 2008 All rights reserved

Legend

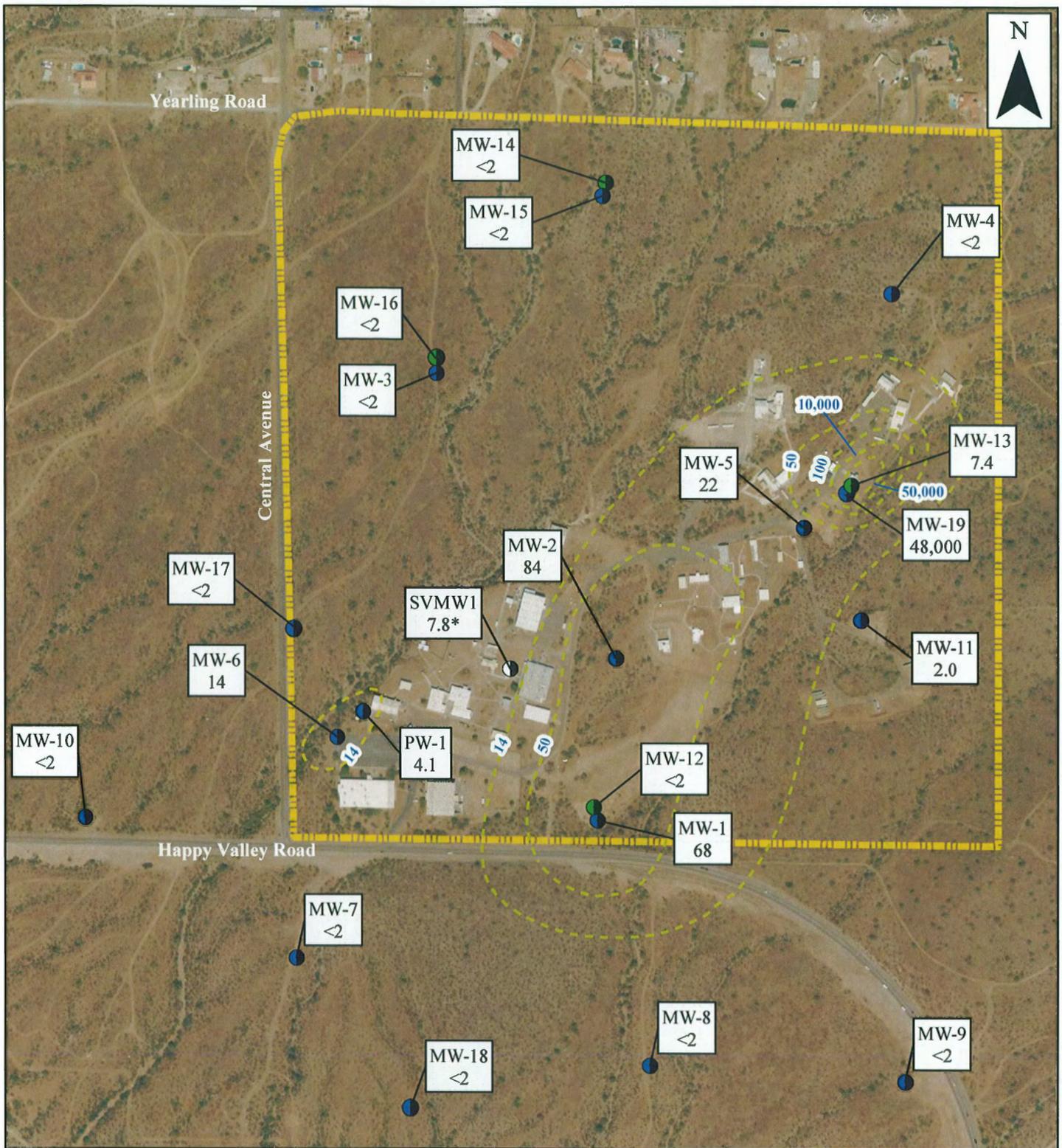
- Deep Well
- Monitor Well
- ▭ Lease Property Boundary



Site Monitor Well Locations
 Corrective Measures Study
 Work Plan
 Universal Propulsion Company, Inc.

December 2011

Figure 4



Aerial Photo copyright Landiscor, Inc. 2008 All rights reserved

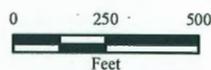
Legend

- Deep Well
- Monitor Well
- Soil Vapor Well
- ▭ Lease Property Boundary
- - - Inferred Perchlorate Contours

MW-11 Well ID
 2.0 Perchlorate Concentration (µg/L)
 * Shallow Groundwater Grab Sample



Perchlorate Concentration
 in Groundwater Above
 Remediation Goal
 Corrective Measures Study
 Work Plan
 Universal Propulsion Company, Inc.

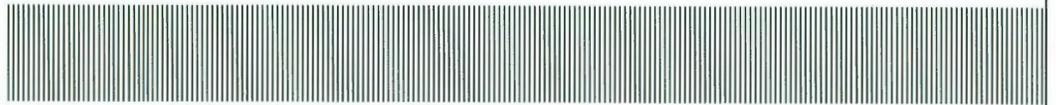


December 2011

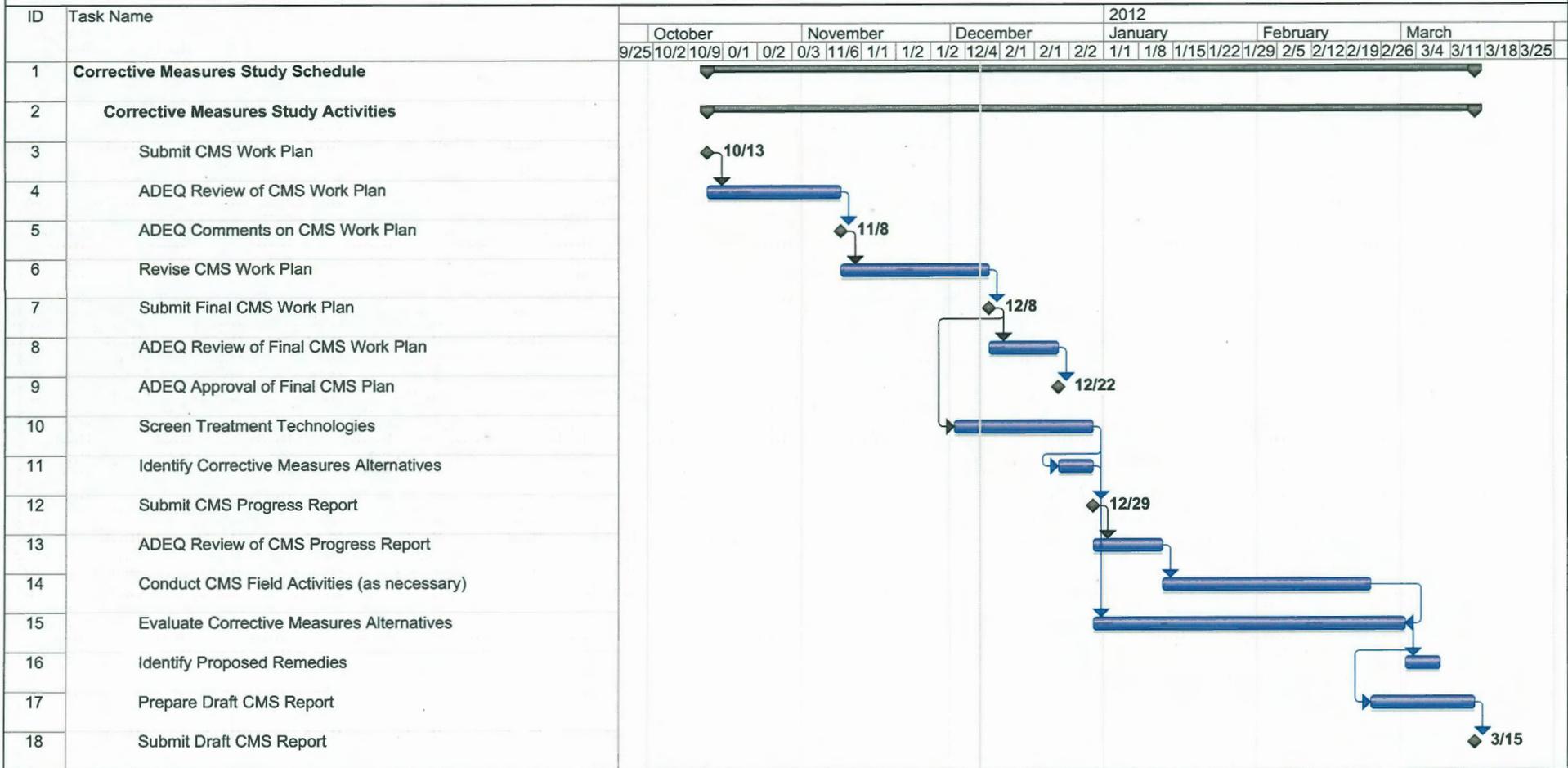
Figure 5

Universal Propulsion Company
Corrective Measures Study Work Plan

Appendix A
CMS Schedule



**Estimated Corrective Measures Study Schedule
 Universal Propulsion Company, Inc.
 Former Phoenix, AZ Facility
 December 2011**



Project: CMS-Schedule 2011-12-07 Date: Wed 12/7/11	Task		Milestone		External Tasks	
	Split		Summary		External Milestone	
	Progress		Project Summary		Deadline	