REPORT ON
SOURCE AREA REMEDIATION FOCUSED
FEASIBILITY STUDY
PHOENIX-GOODYEAR AIRPORT-NORTH SUPERFUND SITE
FORMER UNIDYNAMICS FACILITY
GOODYEAR, ARIZONA

by

Haley & Aldrich, Inc.
Phoenix, Arizona

Registered Professional Engineer (Civil)
CERTIFICATE NO.
53413
TIMOTHY D.
SCHUMACHER
Date Signed 11/1/13
ARIZONA U.S.A.
Expires 6/30/15

for

Crane Co.
Stamford, Connecticut

File No. 37639-012
01 November 2013

APPENDIX A

Groundwater Remediation Technology Screening Tables I and II

TABLE A-1
PRELIMINARY REMEDIAL TECHNOLOGY SCREENING FOR THE SOURCE AREA FOCUSED FEASIBILITY STUDY
PHOENIX-GOODYEAR AIRPORT-NORTH SUPERFUND SITE
GOODYEAR, ARIZONA

Description:

The following table summarized the groundwater remediation options considered for compounds of concern (COCs) detected above Environmental Protection Agency (EPA) Maximum Concentration Limits (MCLs) in the Source Area at the PGA-North Site. The COCs at PGA-North are trichloroethylene (TCE), cis-1,2-dichloroethylene, vinyl chloride, and perchlorate. This table provides a screening of groundwater remediation technologies for application in the source area.

Remedial Action Objectives (RAO)[1]

1) Eighty percent reduction of mass concentration within treatment area.
2) Reduction of mass flux from the treatment area to prevent COC migration within Subunit A and into Subunit C.
3) Sustained concentration reduction within the treatment area after the first five years of implementation.

General Response Action Area[2]:

The Subunit A aquifer within the 1,000 µg/L TCE concentration contour.

Legend:

(green)	Retained for FFS
(yellow)	Retained for FFS, although preliminary screening indicates technology exhibits greater uncertainty or is generally considered less favorable or more costly than other options.
(red)	Eliminated from further consideration in FF

Technology Class	Process Option	Technical Approach	Implementation Comments	Screening Outcome
Physical Mass Removal (Extraction and Aboveground Treatment)	Pump and Treat (P&T)	Install series of groundwater (GW) extraction wells, piping network, and expand the Main Treatment System (MTS)	Unlikely to meet RAO in reasonable timeframe due to high life cycle costs and low anticipated effectiveness for TCE mass removal in source area, especially considering presence of low permeability zones. Potentially require expansion of treated water re-injection system. See hydraulic barrier option for alternate use of this technology.	Eliminated
	Dual Phase Extraction (hi-vac or vacuum-assisted pumping depending on conductivity)	Install a series of GW extraction wells with piping network to connect to existing Soil Vapor Extraction (SVE) wells and above ground treatment system.	Recent Pneu-log testing results show TCE in soil gas is likely from groundwater diffusion. The greatest mass of TCE is located at a depth beyond the dewatering capabilities of a DPE (dual-phase extraction) system, thereby preventing achievement of RAOs.	Eliminated

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GOODYEAR, ARIZONA

Technology Class	Process Option	Technical Approach	Implementation Comments	Screening Outcome
Physical Mass Removal (continued) (Extraction and Aboveground Treatment)	Air Sparge	Installation of vertical air sparge wells with piping network to connect to existing SVE wells and above ground treatment system.	Will not meet RAOs due to thickness and heterogeneous lithology of Subunit A. Limited radius of influence, especially in low permeability deposits, resulting in development of preferential pathways within the high permeability zones. Not effective with perchlorate.	Eliminated
Containment	Slurry wall	Encircling the target area, thus limiting mass transfer to extended plume.	Possible source control measure or use in conjunction with P&T or zero valent iron (ZVI) permeable reactive barrier (PRB) as a funnel and gate system. Cost prohibitive for source area remediation due to depth of TCE impacts in saturated zone within source area. Passive measure. Source controls with no mass reduction. Unless integrated with funnel and gate concept this option will not meet RAOs.	Eliminated
Barrier Systems (migration control)	Zero valent iron (ZVI) PRB (abiotic reduction pathway)	Barrier to intercept plumes migrating off-Site	Potentially applicable (costs typically high and doesn't address the source area). High mineral content may influence long-term efficacy of granular ZVI. Column study would be necessary to determine longevity, thickness, and safety factor. Will not meet RAOs.	Eliminated
	Anaerobic Bioremediation Barrier	Bio-reactive zone as a barrier to intercept plumes migrating off-Site	See comments on bioremediation effectiveness. Will not meet RAOs.	Eliminated
	Chemical Oxidation Barrier (see chemical oxidation for configuration)	Numerous potential configurations for this barrier. Option 1: periodic injection of oxidant with subsurface recirculation and aboveground mixing and injection stations. Option 2: subsurface injection of persulfate to create a horizontal permeable treatment zone	Longevity and effectiveness of barrier untested in a field setting. Will not meet RAOs in a reasonable (five-year) timeframe. Option 1 will require significant infrastructure and system operation and maintenance. High likelihood of inadequate distribution due to presence of low permeability deposits within Subunit A. Option 2 is in the experimental stage at Dr. Paul Johnson's laboratory at Arizona State University. This technology has not been field tested. See discussion regarding ISCO (define) below.	Eliminated

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GOODYEAR, ARIZONA

Technology Class	Process Option	Technical Approach	Implementation Comments	Screening Outcome
Barrier Systems (migration control)	Hydraulic barrier (P&T)	Series of pumping wells to capture plume at boundary	This option is ongoing and has been a successful technology for plume migration control. There is a potential for this option to be used in combination with other source mass removal technologies	Eliminated as a stand-alone alternative/ Retained as a component technology
Chemical Reduction	Nano-scale ZVI (nZVI) (abiotic reduction pathway)	Injection of iron particles (~30-250 nanometers)	Successful bench and pilot testing has been completed. Injection using jet injection required for distribution as demonstrated through previous pilot tests. Pilot test results have demonstrated high mass reduction percentages, ranging between 60 - 93%. Additional optimization step required for implementation of this technology. Shown in the literature to be effective at destroying perchlorate. Pilot test results are inconclusive. By products of reduction of perchlorate have been detected in the form of chlorate and chlorite.	Retained
	Micro-scale ZVI (abiotic reduction pathway)	Injection of iron particles (>1 micrometer)	Exhibits a longer active life than nZVI, but reactivity is not as high. Distribution limited by particle size and hydraulic fracturing will be required for emplacement. Shown in the literature to be effective at destroying perchlorate.	Retained
Chemical Oxidation	Permanganate	Injection grid with manifold and recirculation, Aboveground station for securing chemicals and pumps	Will require soil oxidant demand (SOD) testing, bench-testing, and pilot-testing. Low total organic carbon content in Subunit A soils results in primary and low oxidant demand from target compounds. Not effective with perchlorate.	Eliminated as a stand-alone alternative/ Retained as a component technology
	Persulfate	Injection grid with manifold and recirculation, Aboveground station for securing and mixing chemicals and housing pumps	Will require SOD testing, bench-testing and pilot-testing. A stronger oxidant than permanganate but still not effective with perchlorate. Production of sulfate radicals requires activation with a base, EDTA-Fe (ethylenediaminetetracetic acid iron), or heat. Additional oxidizing potential not necessary. Permanganate is easier to handle in the field and is just as effective with the oxidation of chlorinated organic compounds. Not effective with perchlorate	Eliminated

TABLE A-1
PRELIMINARY REMEDIAL TECHNOLOGY SCREENING FOR THE SOURCE AREA FOCUSED FEASIBILITY STUDY
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Technology Class	Process Option	Technical Approach	Implementation Comments	Screening Outcome
Chemical Oxidation	Ozone	Grid of sparge points with injection manifold and soil vapor recovery system. Aboveground station for securing chemicals and pumps	Will require SOD testing, bench-testing and pilot testing. Unlikely to meet clean-up goals due to the thickness and heterogeneous lithology of Subunit A. Limited radius of influence, especially in low permeability deposits, resulting in development of preferential pathways within the higher permeability zones. Likely to increase concentrations in soil gas (recontamination of vadose zone), which have been declining and are currently very low. Not effective with perchlorate.	Eliminated
	Advanced Oxidation (ozone + hydrogen peroxide)	Grid of sparge points with injection manifold and soil vapor recovery system. Aboveground station for securing chemicals and pumps	Unlikely to meet clean-up goals due to the thickness and heterogeneous lithology of Subunit A. Limited radius of influence, especially in low permeability deposits, resulting in development of preferential pathways within the higher permeability zones. Likely to increase concentrations in soil gas (recontamination of vadose zone), which have been declining are currently very low. Not effective with perchlorate	Eliminated
Bioremediation	Anaerobic Reductive Dechlorination (ARD)	Passive (Injection Grid) Active (Recirculation)	Applicable and effective with TCE, cis-1,2-DCE and vinyl chloride. High likelihood of success in removing TCE mass. Treatability study was conducted using two concentrations of corn syrup in 2005. Results of the study showed that bioaugmentation may be necessary to stimulate reductive dechlorination. This technology has been shown to be effective in degrading perchlorate.	Retained

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Technology Class	Process Option	Technical Approach	Implementation Comments	Screening Outcome
In Situ Thermal Remediation	Electrical Resistivity Heating / Steam Injection (ERH)	Installation of electrical elements and stainless-steel vapor recovery system	Potentially applicable for TCE and perchlorate in source zone. However, hydraulic conductivity gradients across the site and potential interference from previously injected nZVI may disrupt thermal distribution and will require further evaluation and design consideration. This technology preferentially heats silt/clay dominant deposits and groundwater flow may limit its effectiveness. Technology is very expensive and is energy intensive. Few ERH applications have been completed at this depth or this size.	Retained

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[1] As agreed upon by Crane Co., the EPA, and other stakeholders on 15 September 2011.

[2] This area was selected for FS remedial alternative comparative analysis only, the actual treatment area will be determined during implementation of final remediation alternative.

TABLE A-2
FORMULATION OF GROUNDWATER REMEDIATION ALTERNATIVES
PHOENIX-GOODYEAR AIRPORT-NORTH SUPERFUND SITE
GOODYEAR, ARIZONA

Description:
This table summarizes the retained groundwater remediation technologies and provides preliminary remediation alternatives for evaluation using the nine EPA screening and sustainability cri criteria in the Source Area Remediation Focused Feasibility Study.

Remedial Action Objectives (RAO)[1]
1) Eighty percent reduction of mass concentration within the treatment area.
2) Reduction of mass flux from the treatment area to prevent COC migration within Subunit A and into Subunit C.
3) Sustained concentration reduction within treatment area after the first five years of implementation

General Response Action Area[2]:
The Subunit A aquifer within the 1,000 µg/L TCE concentration contour

Groundwater (TCE, cis-1,2-DCE, VC, and Perchlorate)			
Retained Remediation Technologies		Remediation Alternatives	Description
1	Hydraulic Barrier	Not a stand-alone remedy	Optimization and expansion of existing extraction well network and aboveground treatment through the MTS to control source area Subunit A TCE plume.
2	Nano-scale ZVI	nZVI + ARD + Hydraulic Barrier	Injection of nZVI electron donor and bioaugmentation cultures to chemically reduce COCs within the source area and begin growth of anaerobic degrader populations. Injections would be completed using jet-assisted injection in a staggered grid pattern. Injections will be performed during ongoing operation of a hydraulic barrier as described above.
3	Macro-scale ZVI	ZVI + ARD + Hydraulic Barrier	Injection of micro/macro ZVI, electron donor and bioaugmentation culture to chemically reduce COCs and treatment area and begin growth of anaerobic degrader populations. Injections would be completed using hydraulic fracturing in a staggered grid pattern. Injections will be performed during ongoing operation of a hydraulic barrier as described above.

TABLE A-2
FORMULATION OF GROUNDWATER REMEDIATION ALTERNATIVES
PHOENIX-GOODYEAR AIRPORT-NORTH SUPERFUND SITE
GOODYEAR, ARIZONA

Groundwater (TCE, cis-1,2-DCE, VC, and Perchlorate)			
Retained Remediation Technologies		Remediation Alternatives	Description
4	In-Situ Oxidation (ISO Permanganate)	ISO Permanganate + Hydraulic Barrier	Injection of a potassium permanganate solution to chemically oxidize chlorinated solvents within the source area. Injections would be completed via a network of horizontal wells to target higher permeability lithologic layers. Injections will be performed during ongoing operation of a hydraulic barrier as described above. A pilot test would need to be performed to determine dosage, achievable flow rate and radius of influence.
5	Anaerobic Reductive Dechlorination (ARD)	ARD + Hydraulic Barrier	Injection of electron donor to begin stimulation of anaerobic and reducing conditions. Injections would be completed using hydraulic fracturing in a staggered grid pattern. Injections will be performed concurrent with the ongoing operation of a hydraulic barrier as described above.
6	Electrical Resistivity Heating / Steam Injection	ERH / Steam + Hydraulic Control	The subsurface conditions of Subunit A soil would need to be measured to be assessed to determine applicability and preliminary spacing for the electrodes. Installation of steel casing to be used as electrodes in a 3-phase or 6-phase grid pattern will be required within the treatment area. Vapor extraction wells are typically co-located with the electrodes to capture off-gassing. Treatment will be conducted in phases and electricity applied to reach the boiling point of the water COC mixture. Off-gas would be collected using the existing SVE system when possible. Significant expansion and reconstruction of the SVE system including stainless steel well construction will be required. A hydraulic groundwater system may need to be installed to control the influx of groundwater into the thermally impacted treatment area.

[1] As agreed upon by Crane Co., the US EPA, and other stakeholders on 15 September 2011.
[2] This area was selected for FS remedial alternative comparative analysis only, the actual treatment area will be determined during implementation of final remediation alternative.

APPENDIX B

Response to Comments

Chang, Paula

From:	Brown, Catherine <Brown.Catherine@epa.gov>
Sent:	Friday, October 25, 2013 4:38 PM
To:	Chang, Paula
Cc:	Travis M. Barnum; Michael Long; Al Bilzi; Koehne, Stephanie; Harry Brenton; Bruck, Glenn; Becker, Dave J HNC@NWO; Mark Holmes; Tom Suriano; 'Nancy Nesky'; Ailiang Gu; Dreyfus, Bethany
Subject:	PGA-North Final Changes to SARFFS
Attachments:	2013_0923_37639-002_SARFFS_RF4_revised_section2.10.11redline.pdf

Paula and all,

After reviewing the Revised Final SARFFS from September 2013 and the additional text revision in your email (attached), the Agencies approve of the revisions. Please prepare the final document. Feel free to contact me if there are any questions.

Catherine Brown, RPM
Superfund Program
US EPA Region 9
75 Hawthorne Street
San Francisco, CA 94105
(415)947-4137 (o)
brown.catherine@epa.gov

From: Chang, Paula [mailto:PChang@haleyaldrich.com]
Sent: Thursday, October 24, 2013 3:28 PM
To: Brown, Catherine; Travis Barnum (tb6@azdeq.gov); Dreyfus, Bethany
Cc: Nancy Nesky; mlong@hargis.com; Alan F. Bilzi (abilzi@aol.com); Harry Brenton; Koehne, Stephanie
Subject: PGA-North Final Changes to SARFFS

Dear Catherine,
Per the comments that you passed on to Al Bilzi earlier today, here is a revised Page 60, section 2.10.11. Please let me know if these edits meets your approval. If not, please provide a redline indicating your suggested changes. Upon receipt of your approval, Haley & Aldrich, on behalf of Crane Co. will submit the final SARFFS.

Thank you,
Paula

Paula R. Chang
Remediation Program Manager
Vice President
Haley & Aldrich, Inc.
One Arizona Center
400 East Van Buren Street, Suite 545
Phoenix, Arizona 85004
P: 602.760.2418
F: 602.760.2443
C: 480.239.9641
PChang@HaleyAldrich.com

Chang, Paula

From: Dreyfus, Bethany <Dreyfus.Bethany@epa.gov>
Sent: Thursday, August 22, 2013 10:41 AM
To: Chang, Paula; Joe Drazek (Joe.Drazek@quarles.com)
Cc: Brown, Catherine
Subject: RE: PGA-N Second Revised SARFFS and ARARs Table

Joe and Paula – I have reviewed the revised ARARs table, and it looks good to me but-for 1 small edit. The Arizona Groundwater Management Act should be revised to Relevant and Appropriate. In the comment section, it states that the statute by its own terms does not apply to remedial actions, thus it cannot be "Applicable." However, the substantive requirements can be Relevant and Appropriate to the action, so it should remain in the chart but with the revised designation. I'm not sure who is making the last revisions, but if it's Crane, please make the above change and the table should be good to go.

Thanks for all your work revising the ARARs; the table is now thorough and well done.

Bethany

Bethany Dreyfus
EPA Region IX ORC-3
75 Hawthorne Street
San Francisco, CA 94105
(415) 972-3886
(415) 947-3570 (fax)

From: Chang, Paula [mailto:PChang@haleyaldrich.com]
Sent: Friday, August 02, 2013 1:01 PM
To: Brown, Catherine; Dreyfus, Bethany; Travis Barnum (tb6@azdeq.gov)
Cc: Bruck, Glenn; Nancy Nesky (Nesky@itsi.com); Ailiang Gu; dave.j.becker@usace.army.mil; Douglas Fisher (DFisher@itsi.com); Alan F. Bilzi (abilzi@aol.com); Koehne, Stephanie; Harry Brenton; mlong@hargis.com; Joe Drazek (Joe.Drazek@quarles.com)
Subject: PGA-N Second Revised SARFFS and ARARs Table

Catherine,
On behalf of Crane Co. please find the attached SARFFS text with all responses to comments in red-line format, and the revised ARARs table. If you have any questions or comments on these deliverables, please contact me.

Best Regards,
Paula

Paula R. Chang
Remediation Program Manager
Vice President
Haley & Aldrich, Inc.
One Arizona Center
400 East Van Buren Street, Suite 545
Phoenix, Arizona 85004
P: 602.760.2418
F: 602.760.2443

C: 480.239.9641
PChang@HaleyAldrich.com
HaleyAldrich.com

Chang, Paula

From: Dreyfus, Bethany <Dreyfus.Bethany@epa.gov>
Sent: Monday, July 22, 2013 4:15 PM
To: Drazek, Joseph A.
Cc: Brown, Catherine; Chang, Paula
Subject: PGA-North ARARs comments

Hi Joe. Generally the ARARs table is looking good. Here are my few follow-up questions and comments. The comments I'm referencing are only for reference to my comments of June 11. Let me know if you want to discuss or have any questions. Otherwise I assume Crane can make the referenced changes and the section should be good to go.

1 - Comment 4: Crane has removed National Historic Preservation Act but not the Arizona equivalent. Please explain why one is selected as an ARAR and the other is not.

2 - Comment 5: Generally the revision is very helpful. The only change necessary is that Rule 220, Sections 302 and 303, are noted as relevant and appropriate, though they appear only to require a compliance plan for those sources that violate rules 100 and 140. However, rules 100 and 140 are not ARARs here. If there are not separate substantive compliance plan requirements, these can be removed from the ARARs chart.

3 - Comment 6: The reference to A.R.S. 49-480.04: Facility Discharge Permits can be further refined to subsection (C).

4 - Comment 17: The well location requirements at A.A.C. 12-15-818 appear to have been removed. EPA had commented that the text should explain how this regulation was going to be incorporated into the action, and did not expect it to be removed. Return this requirement as an ARAR for which the substantive requirements are relevant and appropriate.

> *R12-15-818. Well Location* Except for monitor wells and piezometer wells, no well shall be drilled within 100 feet of any septic tank system, sewage disposal area, landfill, hazardous waste facility, storage area of hazardous materials or petroleum storage areas and tanks, unless authorized in writing by the Director.

5 - Comment 20: Regarding the Aquifer Protection Permit, revise the comments section to indicate that CERCLA actions are exempt from obtaining permits rather than exempt from the permit requirements.

Bethany Dreyfus
EPA Region IX ORC-3
75 Hawthorne Street
San Francisco, CA 94105
(415) 972-3886
(415) 947-3570 (fax)

ITSI Gilbane

To:	Catherine Brown, Remedial Project Manager, EPA Region 9
From:	Nancy Nesky, P. E., Senior Project Manager, ITSI Gilbane/Tempe Douglas Fisher, P.E. Senior Project Engineer, ITSI Gilbane/Tempe
Date:	March 22, 2013
Subject:	Evaluation of Draft Applicable or Relevant and Appropriate Requirements and Revised Evaluation of Response to Comments for the Final Source Area Remediation Focused Feasibility Study (SARFFS), Phoenix-Goodyear Airport North Superfund Site, Goodyear, Arizona
Contract /TO:	EP-S9-08-03/ TO 0004 **ITSI DCN:** 07163.0005.0402

ITSI Gilbane Company (ITSI Gilbane), on behalf of the U.S. Environmental Protection Agency (EPA), and EPA have re-evaluated the document titled *Final Source Area Remediation Focused Feasibility Study Response to 14 December 2012 EPA Comments, Phoenix-Goodyear Airport North Superfund Site, Goodyear, Arizona* (Final SARFFS RTC). Haley & Aldrich submitted the document on January 14, 2013, on behalf of Crane Co. Also reviewed was the *Draft Applicable or Relevant and Appropriate Requirements (ARARs) Evaluation* dated February 1, 2013 prepared by Haley & Aldrich on behalf of Crane Co. and submitted as part of the presentation materials for the February 6, 2013 Quarterly Technical Meeting. Below is a summary of the observations made by the Agency Team.

During the First Quarter 2013 Quarterly Project Management meeting on February 6, 2013, the Crane Team clarified that the response "comment noted" in the Response to Comments Table was meant to indicate that the Crane Team agreed with the comment and the change would be made. Based on this clarification, ITSI Gilbane reviewed the outstanding comments not yet evaluated. The attached Revised Agency Evaluation of Response to Comments table summarizes the findings (Attachment 1).

The Agency Team reviewed the Draft ARARs Table for completeness of ARARs for the remedial alternatives discussed in the Final SARFFS dated September 10, 2012, including the No Action Alternative that would continue the current remedial actions of groundwater pump & treat and soil vapor extraction (SVE). Although the Arizona Department of Environmental Quality (ADEQ) did not provide a letter, the EPA RPM noted that during a conversation with the ADEQ Project Manager, it was stated that ADEQ does not have any comments on the Draft ARARs Evaluation Table.

An important consideration regarding the various rules and regulations which may be ARARs for work outlined in the SARFFS (as well as on-going response actions at the Site) is the February 19, 1992 EPA Directive (OSWER Directive 9355.7-03) titled *Permits and Permit "Equivalency" Processes for CERCLA On-site Response Actions*. This directive provides a CERCLA exemption for any federal, state, or local permit required for any activities conducted completely on Site without removing the requirement to meet (or waive) the substantive provisions of permitting regulations that are ARARs.

General Comments – ITSI Gilbane

1. To ensure completeness and clarity, it is noted that CERCLA Section 121, "Cleanup Standards," applies only to remedial actions that the Agency determines should be taken under CERCLA Sections 104 and 106 authority. A "no action" decision typically means that no further remedial action is required as the subject area is already protective of human health and the environment. However, in the Final SARFFS, the "No Action" decision does not meet this intent since existing remedial actions, pump and treat and soil vapor extraction, will continue to occur to provide protectiveness. Thus, it is important to ensure that the Draft ARARs table includes consideration of the remedial actions under the No Action alternative (as defined in the Final SARFFS and accompanying RTC) as well.

Specific Comments – ITSI Gilbane

ITSI Gilbane recommends that the Crane Team add the following Arizona Revised Statute (ARS) rules to the list of ARARs for consideration as part of the SARFFS as an Action-Specific ARAR:

2. ITSI Gilbane recommends that the Crane Team add the following Arizona Revised Statute (ARS) rules to the list of ARARs for consideration as part of the SARFFS as an Action-Specific ARAR:

   ARS 49-281(12)
   "“Remedial actions" means those actions that are reasonable, necessary, cost-effective and technically feasible in the event of the release or threat of release of hazardous substances into the environment, such actions as may be necessary to investigate, monitor, assess and evaluate such release or threat of release, actions of remediation, removal or disposal of hazardous substances or taking such other actions as may be necessary to prevent, minimize or mitigate damage to the public health or welfare or to the environment which may otherwise result from a release or threat of release of a hazardous substance. **Remedial actions include the use of biostimulation with indigenous microbes and *bioaugmentation using microbes that are nonpathogenic, that are nonopportunistic and that are naturally occurring*.** Remedial actions may include community information and participation costs and providing an alternative drinking water supply ***(emphasis added)*.”**

The language in the latter portion of this statute *(emphasized above)* specifically applies to alternatives 3, 4, and 5, which include anaerobic reductive dechlorination (ARD) as part of the remedy. As noted in the description of ARD in the *Final SARFFS*, this involves both bioaugmentation and biostimulation – each with specific limitations as noted in ARS §49-281(12).

3. An additional chemical-specific ARAR applies to Alternative 6, as potassium permanganate is listed as a chemical-of-interest by the Department of Homeland Security (DHS) under 6 Code of Federal Regulations (CFR) Part 27, including § 27.210(a)(1)(i).

If the use of potassium permanganate is selected for the remedy, all requirements listed in 6 CFR 27 must be met prior to transport and storage of the oxidant on site.

4. Two additional location-specific ARARs apply to alternatives which would result in a discharge to a surface water (including all canals):
   a. Arizona's antidegradation rule found at Arizona Administrative Code (A.A.C.) 18-11-107; and the
   b. Federal antidegradation policy at 40 CFR §131.12.
5. The Draft ARARs table references the ARARs found in the Maricopa County Air Pollution Control Rules and Regulations (MCAPCRR) through the following referenced:
   - ARS 49-401-516;
   - ARS 49-480; and
   - ARS49-471 et. Seq. Regulation II, Rule Numbers 200, et. Seq. and Regulation III, Rule 300 et .seq.

However, the final ARARs table should list the specific rules and/or regulations that are considered ARARs so the reviewer knows the specific requirement referenced. Thus, the following ARARs table should include the following MCAPCRR:

Rule #	Title	Description	Applicability
100	General provisions and Definitions	Sets forth the legal authority for the Air Pollution Rules and Regulations and includes definitions of terms used in all Maricopa County Air Pollution Control Rules	This rule tasks the MCAPCD with regulating air pollutants originating from within Maricopa County. The Site is within Maricopa County borders and, depending on the technology selected, could be an air emissions source and is therefore under the jurisdiction of MCAPC
110	Violations	Describes orders of abatement, civil, and criminal penalties for violations	Rule 110 gives the MCAPCD Director authority to issue orders of abatement and/or notices of violation to parties within the borders of Maricopa County that fail to comply with MCAPCD rules. The Site resides within Maricopa County borders and, depending on the technology selected, could be an air emissions source that potentially fails to comply with MCAPCD rules.
140	Excess Emissions	Establishes criteria and administrative requirements for emergencies	Rule 140 provides owners of emissions sources with an affirmative defense in the event of excess emissions due to a malfunction or during startup/shakedown of a system. If the selected remedy uses a technology that emits regulated pollutants due to one of these cases they would potentially be protected by this rule.

Rule #	Title	Description	Applicability
200	Permit Requirements	Describes all types of permits required and issued	Rule 200 lists types of permits and standards and guidelines of each. If the selected remedy has the potential to emit regulated air pollutants the Site will be required to meet the substantive portions of this rule.
220	Non-Title V Permit Provisions	Describes Non-Title V permit requirements, application procedures for new Non-Title V sources and application procedures for modifications to existing Non-Title V sources	Rule 220 primarily provides a process for obtaining a non-Title V permit for non-Title V emission sources which is not applicable to the Site. It does however require a compliance plan for a source that violates Rules 100 and 140. If the selected technology utilizes a technology that emits regulated air pollutants and subsequently violates any part of Rules 100 and 140 the Site would potentially have to develop a compliance plan to address how it will correct violations in the future.
270	Performance Tests	Includes supportive data for good maintenance and operating practices, performance test requirements, and testing criteria of stationary sources	Rule 270 establishes performance testing requirements for air emission sources. If the selected remedy includes a technology that emits regulated pollutants it would be subject to the substantive portions of this rule.
300	Visible Emissions	Describes standards for visible emissions and opacity	Rule 300 places limits on visible emissions; should the chosen remedy include a source that has visible emissions the Site would be subject to the substantive portions of this rule.
320	Odors and Gaseous Air Contaminants	Establishes limits for the emissions of odors and other gaseous air contaminants into the atmosphere	Rule 320 places limits on odors and other gaseous emissions emissions; should the chosen remedy include a source that has odorous or gaseous emissions the Site would be subject to the substantive portions of this rule.
370	Federal Hazardous Air Pollutant Program	Describes emission standards for federally listed hazardous air pollutants	Rule 370 set emissions standards (by reference) for federally listed hazardous air pollutants (HAPs). Pollutants that have been or are present in the source area are included in this list. Dependent on the selected remedy there is a potential to emit these HAPs therefore the substantive portions of this Rule would apply.
372	Maricopa County Hazardous Air Pollutants (HAPs) Program	Describes Maricopa County's program for the regulation of hazardous air pollutants (HAPs)	Rule 372 To implement/establish procedures for a Maricopa County program for the regulation of federally listed HAPs. Because Site COCs include HAPs the Site is subject to the substantive portions of this Rule.

EPA also prepared both General and Specific comments for the Draft ARARs Evaluation Table. Those comments are provided below.

General Comment:

6. The ARARs table should explain how the ARAR or TBC applies to the alternatives under consideration. This can be done in the comments section or a separate column can be inserted.

Chemical Specific ARARs:

7. **Health Advisories:** This column should be renamed to reflect Arizona designation of Health Based Guidance Levels (HBGLs).
8. **Health Advisories/HBGLs:** Health Advisories generally are correctly designated as To Be Considered requirements, or TBCs, because they are not promulgated standards. Such standards may be used in developing risk-based standards for a CERCLA cleanup. Once selected, ARARs become enforceable standards. The Preliminary Determination column should be changed to TBC, and the Description column should remove the reference to enforceability and state that these requirements are not promulgated.
9. **Health Advisories/HBGLs:** The HBGLs that are potential ARARs or TBCs for this response action should be identified. Specifically, the chart should reference Arizona's HBGL for perchlorate.
10. **Regional Screening Levels**: The Regional Screening Levels, or RSLs, are potential TBCs for this action. They are risk-based screening levels. Although they are called "regional," RSLs are in fact applied EPA-wide.
11. **City of Goodyear Code:** ARARs are only federal and state promulgated standards, not local ordinances.
12. **Site-specific Action Level:** Generally, site specific action levels determined in other decision documents would not be ARARs. As with the RSLs, the site-specific action level for perchlorate may be used as a TBC.
13. **Arizona Laws:** The State of Arizona was provided this draft concurrent with EPA. Therefore this section may be amended to include state requirements that have not yet been considered.
14. **Arizona Drinking Water Standards:** State standards are only ARARs where they are more stringent than federal standard. If there are any more stringent drinking water standards that would be applicable or relevant and appropriate for this action, those should be specifically identified here.
15. **Arizona Aquifer Water Quality Standards:** State standards are only ARARs where they are more stringent than federal standard. If there are any more stringent drinking water standards than EPA's MCLs that would be applicable or relevant and appropriate for this action, those should be specifically identified here.

16. **Soil Remediation Levels:** Explain how the Arizona Soil Remediation Levels, or SRLs, are implicated by this action. If the SRLs are applicable or relevant and appropriate for this action, the particular SRLs should be identified here.

<u>Location Specific ARARs:</u>

Location-specific ARARs are requirements that arise due to the location of the action. This section currently includes several statutes that do not appear to be in any way related to this action. Specifically, the Wilderness Act, the Fish and Wildlife Coordination Act, the Wild and Scenic Rivers Act and the Coastal Zone Management Act all on their face appear to be inapplicable to the Site location. However, because they were raised, provide an explanation of why they either would or would not be applicable here.

17. **National Historic Preservation Act (NHPA):** The NHPA is primarily a procedural statute, and CERCLA ARARs only apply to substantive requirements. In many cases, however, the way to ensure compliance with substantive requirements is to utilize certain procedures provided by the statute. First, clarify how the NHPA is applicable or relevant and appropriate for this action. Second, the comments should explain that it is the substantive provisions of the NHPA that must be followed. Finally, the specific comment section should include how the ARAR applies to the alternatives and the impact on the action should any archaeological artifacts, human remains, or funerary objects be discovered during construction.
18. **Arizona Historic Preservation and Archaeological Discovery:** As with the NHPA, it would only be the substantive provisions of these statutes that would be applicable or relevant and appropriate for this action. Additionally, it is only the requirements that are more stringent than the federal requirements that would be potential ARARs. Those provisions should be specifically identified here. The specific comment section should include how the ARAR applies to the alternatives and the impact on the action should any archaeological artifacts, human remains, or funerary objects be discovered during construction.
19. **Endangered Species Act:** As with the NHPA, the ESA has significant procedural components, and CERCLA ARARs only apply to substantive requirements. In many cases, however, the way to ensure compliance with substantive requirements is to rely on certain procedures provided by the statute. However, first it must be determined whether the statute is in any way implicated by the action being taken. The Screening Level Ecological Risk Assessment for the Main Dry Well Source Area (2013) did not identify any endangered or threatened species or their habitat in the area. Accordingly, the ESA would not be relevant and appropriate to this action. This should be explained in the comment section.
20. **Clean Water Act §404 Permit Requirements:** Specify how this action involves navigable waters, and, if so, which substantive provisions of Section 404 would be implicated by this action.
21. **Floodplain Management (federal and state):** Explain why these requirements would be applicable or relevant and appropriate for this action. If they are, specify the

requirement under the federal and state regulations that would be ARARs. For the state requirements, specify which ones are more stringent than federal requirements.

Action-Specific ARARs:

22. **Clean Air Act and Arizona Clean Air Act:** Specify which portions of Part 50 of the Clean Air Act and of the ARS §49-401 through 516 are potential ARARs for this action. Note that the comments should be corrected to reflect that the federal requirements are implemented through state plans.
23. **Facility Discharge Permits:** Specify which portions of ARS §49-480 are potential ARARs for this action. Note that CERCLA actions themselves do not require permits; however, the action must comply with any substantive requirements selected as ARARs.
24. **County Air Pollution Control:** Specify which portions of ARS §49-471 et seq. and Regulation II, Rule 200 et seq, and Regulation III, Rule 300 et seq are potential ARARs for this action. These requirements may be state ARARs albeit administered at the county level.
25. **Arizona Groundwater Management Act**: The substantive requirements of these regulations are potential ARARs for this action. Specific requirements within the statute should be identified as potential ARARs. Also, the comments section should elaborate on the meaning of "certain provisions."
26. **Hazardous Waste Determination:** The comment section should explain how this ARAR applies to the alternatives under consideration.
27. **Arizona Water Quality Standards and NPDES Program:** First, identify whether any of the alternatives under consideration use discharge to surface water. Then, note that state requirements are only ARARs where they are more stringent than federal requirements. The NPDES Program section should identify which parts of Parts 122 and 125 are potential ARARs for this action.
28. **Aquifer Identification, Classification, and Reclassification:** This should be moved to the location-specific ARARs section
29. **Federal Clean Water Act:** First, address whether any alternatives under consideration will be discharging to a POTW. If that is the case, identify the specific provisions within 40 CFR §403 that would potentially be ARARs for this action. Additionally, the Maricopa County Code would not be an ARAR unless the county is implementing state regulations.
30. **Federal Clean Water Act:** Add Clean Water Act §402, 33 U.S.C. §1342; SWPCB Order Number 92-08-DWQ, NPDES General Permit Number CAS000002 (Waste Discharge requirements for Discharges of Storm Water Associated with Construction Activity). This is applicable to construction activities affecting more than 5 acres, and it may be relevant and appropriate to such activities affecting fewer than 5 acres. The comment should include how this ARAR applies to the alternatives under consideration.
31. **Well Location:** Explain how this regulation would be incorporated into this action.

32. **OSHA:** OSHA is generally a worker protection statute, not an environmental statute. As such, it would not be an ARAR. Accordingly, unlike ARARs, they cannot be waived, and both procedural and substantive requirements apply.
33. **RCRA:** Specify which provisions of 40 CFR §260 et seq and ARS §49-901 through 973 are potential ARARs for this action. For example, the substantive requirements in 40 CFR 264 and AAC R18-8-264 may be relevant and appropriate to storage and disposal of hazardous wastes generated onsite. These requirements include container storage, secondary containment, and leak detection. Offsite disposal of hazardous waste also meet the requirements in these sections, including those for notification, disposal methods, and transport. Identify if there are other portions of 40 CFR §260 et seq that are potential ARARs for this action.
34. **Hazardous Waste Transportation:** Specify which portions of 49 CFR Subsection C are potential ARARs for this action. Also, 10 CFR §71 and 20.2006 apply to transportation of low level radioactive waste materials. Explain how these regulations would be potentially applicable or relevant and appropriate for this action.
35. **Aquifer Protection Permit:** The comment section for this potential ARAR should be edited to explain how the substantive requirements of the Arizona Aquifer Protection (APP) Permits are relevant and appropriate to injection for this action. Specifically, the APP program requires that any discharges to the aquifer must not cause or contribute to a violation of AWQS. Additionally, explain how groundwater rights are potential ARARs for this action.
36. **Groundwater Rights and Permits:** It is unclear from this description how this permit requirement is an ARAR for this CERCLA action.
37. **Safe Drinking Water Act:** Revise comment to better explain how this ARAR applies to the alternatives under consideration.

As noted during discussions at the February 6, 2013 PGA North Quarterly Technical Meeting, the Crane Team will prepare a revised Draft ARARs Evaluation Table to be submitted along with the revised portions of text as noted on the attached table (Attachment 1). Following acceptance by the Agency Team of those materials, the Revised Final SARFFS can be prepared.

Please contact Nancy Nesky (480-706-6488, ext. 4712; nnesky@itsi.com), with any questions about this technical memorandum.

Attachments (2)

1. Revised Agency Evaluation of Response to Comments Table
2. *Permits and Permit "Equivalency" Processes for CERCLA On-site Response Actions* dated February 19, 1992 *(*OSWER Directive 9355.7-03

cc: ITSI Gilbane Project File (electronic copy)

ATTACHMENT 1

Revised Agency Evaluation of Response to Comments Table for the
Source Area Remediation Focused Feasibility Study Report (SARFFS)
Response to 14 December 2012 EPA Comments
January 14, 2013
PGA North

Revised Agency Evaluation Table to Response to Comments on Final SARFFS (New Evaluation Noted in RED ITALICIZED Text)

Report Titled, "Source Area Remediation Focused Feasibility Study Report (Final SARFFS Report) Response to 14 December 2012 Comments, Phoenix-Goodyear Airport North Superfund Site, Goodyear, Arizona," submitted by Haley & Aldrich on 14 January 2013 - and as discussed during the Quarterly Technical Meeting on February 6, 2013

Phoenix-Goodyear Airport North Superfund Site

Comment Number	Reviewer(s)	Section(s)	Page(s)	Figure(s)	Table(s)	Comment from Agency Team	Crane Team's Response to Comment	Agency Team's Evaluation of Response to Comment
General (Gen-) Comments								
Gen-1	ITSI Gilbane					The SARFFS report is strongly biased toward the anaerobic reductive dechlorination (ARD) with zero valent iron/nano-scale zero valent iron (ZVI/nZVI) alternative and ARD with ZVI when discussing the impact of the remedy on groundwater quality. The report still overstates the impact of ISCO using permanganate on downgradient groundwater and the treatment system (precipitation of manganese oxide, carbonate, persistence of permanganate, chromium mobilization, etc.), while it understates the impact of ARD (potential arsenic mobilization, bio-fouling of injection wells and extraction wells).	The Crane Co. team does not believe the SARFFS report to be strongly biased; however, the report will be reviewed and the language adjusted as appropriate. We agree that both the ZVI/nZVI + ARD and in-situ oxidation (ISCO) alternatives may have impacts to groundwater quality that are similar in magnitude. The major difference between the two remedies remains that the remediation alternative including ARD will treat perchlorate, one of the two contaminants of concern, and the ISCO alternative will not.	Response noted. The perceived bias noted by the Agency Team can be discussed during the February 6, 2013, Quarterly Technical Meeting. Resolution of this comment is expected at that time. Crane Co.'s response indicates that they will review the draft SARFFS report and adjust language to address perceived bias in its evaluation; however, Crane Co continues on to highlight the potential for the ZVI and ARD approach to address perchlorate. Clear Creek notes that the magnitude of perchlorate impacts in the source area is far less than the magnitude of TCE impacts in the source area. Accordingly, the primary consideration should be the remedial alternatives potential effectiveness in meeting remedial objectives for TCE. Additionally, for nZVI alternatives that rely on jet assisted injection, field evidence is currently lacking to demonstrate this techniques' effectiveness to emplace a nZVI barrier of sufficient thickness throughout the targeted depth interval. This uncertainty is understated in the draft SARFFS. Finally, the uncertainty associated with the sustainability of the chloroethene degrading microorganisms (as recognized in Crane Co.'s response to General Comment No. 5 [CH2M Hill]) is also understated in the draft SARFFS.

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Gen-2	ITSI Gilbane					The text states that the 12 proposed new monitor wells will be installed in a period of 3 to 4 years. It seems to be more beneficial to install all the monitor wells before the initiation of the remediation to better define the targeted treatment zone and better characterize Subunit A in the targeted treatment zone. This is especially true for the eight proposed monitor wells that are outside the active injection area.	For the SARFFS remediation alternatives that include jet-assisted injection (ARD, ZVI/nZVI+ARD, and ISCO), installation of monitoring wells prior to injection may cause damage, if not complete failure of the monitor wells. Determination of monitoring well locations for these alternatives is intended to be part of the iterative real-time execution of a Triad approach. The Triad approach would include definition of the treatment zone through measurement of trichloroethene (TCE), daughter products, and perchlorate concentrations in hydropunch samples collected during drilling of injection well boreholes in an offset grid pattern. The locations and screen intervals for the injection and monitoring wells would be determined at this time and in accordance with the depth of the bulk of the contaminant mass. The final decision process for determination of location and depths of the injection and monitoring wells will be drafted during the design phase of the remedy and will be subject to approval from the EPA and other stakeholders at that time.	We agree that the locations of the monitoring wells should be mainly based on Triad approach; however, the proposed monitoring wells outside the target treatment zone will not likely be impacted by the jet-assisted injection. Installation of those monitoring wells will help to define the targeted treatment zone and potentially result in cost saving with a smaller treatment zone. We can discuss it during the February 2013 quarterly meeting. We agree that this item should be addressed in the design phase of the proposed remedy.
Gen-3	USACE					It was surprising and disappointing that the focused feasibility study still appears to provide a biased presentation, particularly of the in-situ chemical oxidation (ISCO) alternative. The impacts related to the potential mobilization of chromium, migration of permanganate, and the impact on the main treatment system (MTS) from residual permanganate is somewhat overstated. This is particularly true relative to the presentation of the potential mobilization of arsenic, impacts of biofouling on the wells and plant, and the migration of anaerobic water for the bioremediation alternatives. The use of the ARD with ZVI/nZVI is supported, but the key difference is the treatment of perchlorate. The ground water extraction system is an appropriate remedy for a highly mobile constituent like perchlorate; however, the recent increase of perchlorate concentration to over 50 ug/L in MW-04 is significant, and it does seem that the Agency Team is anxious to treat perchlorate beyond the current ground water extraction.	The SARFFS report will be reviewed and the language adjusted as appropriate. Although both the ZVI/nZVI+ARD and ISCO alternatives may have impacts to groundwater quality and aboveground and subsurface groundwater treatment system infrastructure that are similar in magnitude, the Crane Co. team agrees that the major difference between the two remedies is that the ZVI/nZVI+ARD alternative will treat perchlorate and ISCO alternative will not.	Without seeing the revised language, it is difficult to accept this comment as provided; however, the perceived bias noted by the Agency Team can be discussed during the February 6, 2013, Quarterly Technical Meeting. Resolution of this comment is expected at that time.
Gen-4	ADEQ					As noted in the Monthly PM Call held with the PGA North Team on December 6, 2012, the Arizona Department of Environmental Quality (ADEQ) comments provided in Attachment 1 of this document are items that should be considered moving forward in this phase of the project. To be complete, these comments are provided here by reference but, as noted by Travis Barnum during the PM Call, these comments do not require a written response in the Responsiveness Summary.	The ADEQ's comments are acknowledged and will be considered as we move forward to the design phase of the project.	Acceptable Response.

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Phoenix-Goodyear Airport North Superfund Site

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Gen-5	CH2M Hill	3.3 and 3.4			3	The draft FSA strongly advocates the anaerobic reductive dechlorination (ARD) with macro-scale zero-valent iron (ZVI)/nano-scale ZVI (nZVI) alternative described in Alternative 4. Comparative analysis still does not seem to present an objective and balanced view of the benefits and drawbacks of the proposed alternatives. For example, mobilization of arsenic and the production of an anaerobic plume through the use of nZVI and ZVI are potential disadvantages that are of equal significance as the potential for In-Situ Chemical Oxidation (ISCO) to result in permanganate persistence in the aquifer, yet these alternatives are described with differing potential for success. Additionally, perchlorate will not degrade with nZVI or ZVI without the presence of active bioremediation as a polishing step. Currently, it is not known if an active biological population will be sustainable at the project site. This is an important understanding to the use of the nZVI/ZVI technologies, and as such, these technologies should not rank higher than the ISCO alternative for Long-Term Effectiveness and Permanence. ISCO should rank very similarly with any ZVI/nZVI technologies, and both should be a contingent consideration for site use if the eventual preferred alternative does not meet the necessary remedial criteria and performance measures to be established in the remedial design/remedial action process.	The SARFFS report will be reviewed and the language adjusted as appropriate. The Crane Co. team agrees that the magnitude of impacts to groundwater quality and aboveground and subsurface groundwater treatment system infrastructure from both the ZVI/nZVI+ARD and ISCO alternatives may be similar, and that the major difference between the two remedies is that the ZVI/nZVI+ARD alternative will treat perchlorate by using the active bioremediation as a polishing step and the ISCO alternative cannot. The fact gives the ZVI/nZVI+ARD a distinct advantage in Long-Term Effectiveness and Permanence when compared to ISCO alternative. There are many bioremediation projects that demonstrate successful development of anaerobic and reducing conditions, and growth of degrader populations resulting from the injection of an electron donor into groundwater. The Crane Co. team acknowledges that at this time the sustainability of chloroethene degrading microorganisms in Subunit A is unproven. However, perchlorate biodegradation is facilitated by microorganisms that are ubiquitous in aquifers [Logan, B.E. (2001) Assessing the Outlook for Perchlorate Remediation. Environ. Sci. & Tech., 35, 482]. The conditions at PGA-North are unlikely to prevent growth of the indigenous microbial population resulting in the consumption of oxygen, and conversion to anaerobic and reducing conditions, and that those conditions can be maintained in the presence of excess electron donor. Finally, the Crane Co. team believes that the groundwater remediation alternative chosen as a contingency need not be considered equivalent to the recommended alternative.	Acceptable Response. The potential advantage for ISCO to diffuse into fine grained and no flow zones, thereby reducing the potential for back diffusion of TCE over time, is understated in the draft SARFFS. See also Comments to Gen-1.

United States Environmental Protection Agency

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Phoenix-Goodyear Airport North Superfund Site

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Major (Maj-) Comments								
Maj-1	EPA	1.1	1			This section should discuss the 1989 Record of Decision (ROD) and PGA-North remedy in place. This is necessary for context that this is for an amendment to that remedy decision in order to speed reduction in persistent source area contamination despite 20 years of treatment rather than a replacement for the remedy.	The comment is noted and a discussion of the 1989 ROD and the PGA-North remedy in-place will be incorporated into the Revised Final SARFFS Report as requested.	Acceptable Response. *Updated: During the 2/6/2013 Quarterly Meeting, the Crane Team noted that draft text changes as a result of the Agency Team comments would be submitted for review in advance of the Revised Final SARFFS. With this understanding, the Agency Team looks forward to reviewing the revised language per the original comment in the next RTC in advance of receiving the Revised Final SARFFS.*
Maj-2	EPA	1.2.2	2-5			The Site history requires significant revision.	The comment is noted and Section 1.2.2 will revised to include additional information about the Site History.	*Accepted with Comment: During the February 6, 2013, Quarterly Meeting, the Crane Team clarified that "comment noted" meant that Crane accepts this comment and the revised text will be reflective of the Agency Team's comment. With this understanding, the Agency Team looks forward to reviewing the revised language per the original comment in the next RTC in advance of receiving the Revised Final SARFFS.*
Maj-3	EPA	1.2.2	2-5			Significant Site information has been amassed since the 1989 remedial investigation/feasibility study (RI/FS) about Site soils, soil gas, and groundwater. The breadth of nature and extent information accumulated since 1989 must be noted in the FFS and must be made available in the Administrative Record.	The comment is noted and Section 1.2.2 of the Revised Final SARFFS will be updated to include the information accumulated since 1989.	*Accepted with Comment: See response to Comment Maj-2.*
Maj-4	EPA	1.3	11			The FFS does not provide sufficient context regarding the remedy in place and the FFS role with respect to that remedy. The current remedy is progressing toward meeting remedial goals and applicable or relevant and appropriate regulations (ARARs), albeit slowly. This FFS is being undertaken to explore ways to expedite the path toward cleanup. In order to do this, the document should set forth the remedial action objectives (RAOs), ARARs, and remedy from the 1989 ROD and relevant Explanations of Significant Difference (ESDs).	As noted in the response to Major Comment No. 1, discussion of the 1989 ROD and the PGA-North remedy-in-place relative to the RAOs and ARARs will be added to the Revised Final SARFFS Report as requested. However, Section 1.3, page 11 currently discusses the History of Remediation Activities – Treatability and Pilot Studies for source area groundwater at PGA-North.	*Accepted with Comment: See response to Comment Maj-2.*

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Maj-5	ITSI Gilbane	2.2	15			The second RAO agreed to during the September 15, 2011, technical meeting was to achieve an 80% reduction in mass flux from the source area. These RAOs were further documented in an e-mail from Catherine Brown on October 21, 2011 (Attachment 3). While the specifics of the mass flux may be defined in future documents, the SARFFS should reflect the agreed-upon RAOs correctly. It is also recommended that two extraction wells be installed in the target treatment zone for mass flux monitoring for indication of interim remedy effectiveness.	The comment is noted and even though the wording of the RAOs is different, the meaning is ultimately the same. The exact wording from the above referenced e-mail will be substituted in accordance with this comment. To address the second part of the comment regarding the need for installation of two extraction wells, we believe the use of new extraction wells for mass flux monitoring is not appropriate. For example, 1) extracted groundwater will contain amendment and products that will foul components of the Main Treatment System; 2) the capture zone associated with two new extraction wells will extend beyond the treatment area resulting in dilution and the collection of performance data not representative of actual geochemical conditions within the treated source area; and 3) similar to General Comment #2, it is likely that these wells could be destroyed during subsequent jet assisted injections of amendment. Target treatment zone wells can be addressed in the design and implementation phases of the project.	We agree that the interim remedy effectiveness issue could be addressed in the design phase of the remedy. No matter what methods are used for mass flux evaluation - transect method, well capture/pumping test method, passive flux meters, or contaminant transport model - a robust groundwater monitoring program will need to evaluate the interim effectiveness of the remedy. We could discuss this issue during our February 2013 quarterly technical meeting. *Updated: During the 2/6/2013 Quarterly Meeting, the Crane Team noted that draft text changes as a result of the Agency Team comments would be submitted for review in advance of the Revised final SARFFS. With this understanding, the Agency Team looks forward to reviewing the revised language per the original comment in the next RTC in advance of receiving the Revised Final SARFFS.*
Maj-6	EPA	2.2	15			Specific to the RAOs, the 1989 ROD contains RAOs for containment and restoration of groundwater throughout the aquifer. With those in place, the RAOs for any action arising from this FFS should proceed based on the original RAOs. There should also be an explanation for how these RAOs are helping to meet the original ones. For instance, if this is the case, we can explain that, in order to achieve restoration in any reasonable timeframe, EPA has determined that an 80% reduction in source mass is necessary.	The comment is noted and language to this effect will be added to Section 2.2.	Acceptable Response. *Updated: During the 2/6/2013 Quarterly Meeting, the Crane Team noted that draft text changes as a result of the Agency Team comments would be submitted for review in advance of the Revised final SARFFS. With this understanding, the Agency Team looks forward to reviewing the revised language per the original comment in the next RTC in advance of receiving the Revised Final SARFFS.*

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Maj-7	EPA	2.2.1	15-16			Remove the term "secondary COC" wherever it is used. Perchlorate is a contaminant of concern (COC). More context regarding perchlorate at the Site would be helpful in explaining its role in the amended remedy. Specifically, this section merely states that the perchlorate is "above 14," but past levels found and current levels are relevant to determining the method to address it. It should be explained clearly in the FFS that perchlorate cannot always be treated with the same technologies as volatile organic compounds (VOCs). Finally, the document must set forth the Site's perchlorate decision history; specifically it should explain that EPA issued a Removal Action Memorandum requiring treatment of perchlorate when it is removed from the aquifer in order to protect human health, but that to date there has not been full analysis of aquifer restoration for perchlorate.	The term "secondary COC" referencing perchlorate will be removed from the Revised Final SARFFS Report as the Crane Co. team agrees that perchlorate is a primary COC at the site. Additional information regarding the nature and extent of perchlorate impacts in groundwater at PGA-North will be added to Section 1.2.3.1, Nature and Extent of Contamination. Expansion of this section may also include a discussion of the spatial distribution of TCE in groundwater at PGA-North to address Major Comment No. 3. Furthermore, an explanation of how in-situ treatment of perchlorate can only be achieved by the remediation alternatives which include bioremediation will be added to Section 3.1, Development of Alternatives. A subsection will be added to Section 1.2.2, Site History, to discuss perchlorate. This section and Section 2.2.3 ARARs will include discussion of the EPA issued Removal Action Memorandum requiring treatment of perchlorate.	By limiting the discussion to in-situ technologies, Crane Co.'s response does not appear to fully address EPA's comment. *Updated: During the 2/6/2013 Quarterly Meeting, the Crane Team noted that draft text changes as a result of the Agency Team comments would be submitted for review in advance of the Revised final SARFFS. With this understanding, the Agency Team looks forward to reviewing the revised language per the original comment in the next RTC in advance of receiving the Revised Final SARFFS.*
Maj-8	EPA	2.2.2	16			The statement that exposure north of the facility will be controlled by health and safety measures needs further elaboration. It is unclear whether this is where it is intended to insert information about institutional controls. Note also that, at the facility at this point, there are few buildings, but ICs will be necessary to ensure that the land use does not change, and, if it does, that the remedy is protective for occupants of any overlying buildings.	The statement is not intended to insert information regarding institutional controls, but rather provide assurance that remediation activities that may potentially take place north of the property boundary would represent no significant risk to workers during implementation of the remedy due to the use of appropriate health and safety measures. None of the active components for any of the remedial alternatives are anticipated to be completed under buildings; therefore ICs are not deemed necessary for areas outside the property. The Consent Decree contains language for future uses of the property and these requirements will be considered in the design phase.	*Accepted with Comment: During the 2/6/2013 Quarterly Meeting, the Crane Team noted that draft text changes as a result of the Agency Team comments would be submitted for review in advance of the Revised final SARFFS. As such, it is requested that the revised text for this Section contain information regarding how the institutional controls required by Section IX of the 2006 Consent Decree will be addressed with respect to the remedial alternatives identified in the SARFFS.*

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Phoenix-Goodyear Airport North Superfund Site

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Maj-9	ITSI Gilbane	2.2.3				The entire ARARs section is lacking definition and completeness. Although many of the ARARs defined during the previous feasibility study process may remain applicable, additional ARARs would be applicable to the alternatives discussed in this report. Further, during the public comment process for this phase of the project, it is not appropriate to simply reference an outdated list of ARARs. An updated list of ARARs specific to the alternatives discussed in this report is required. As a reference, a sample table of ARARs (not specific to this project) has been prepared to provide an example of how ARARs can be presented to ensure that all ARARs are considered and understood (Attachment 4). Attachment 5 includes a copy of Appendix E - Documentation of ARARs, from the RI/FS Guidance document that was to be followed for preparation of this report, as noted in previous agency comments. As noted in this attachment, the Crane Team is expected to consult with USEPA and ADEQ regarding development of the ARARs. As such, a specific call to discuss ARARs for the SARFFS is recommended.	The Crane Co. team has sufficient information from past experience in EPA Region 9 and in Arizona to compile an updated list of ARARs for the Revised Final SARFFS Report without convening a meeting. Section 2.2.3 will be expanded to include the requested ARARs information.	Acceptable response with comment. Although a draft of the proposed ARARs was not provided for review by the Agency Team, these will be discussed during the PGAN Quarterly Technical Meeting on February 6, 2013. Also, in the event that the Agency Team has comments on the proposed ARARs provided in the Revised Final SARFFS, the Agency Team has the opportunity to revise the ARARs in the Summary of "Remedial Alternatives Section" of the *Proposed Plan* as noted in EPA Guidance EPA 540-R-98-031, *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents*. It would be helpful if a draft of the Proposed ARARS could be made available for the Quarterly Technical Meeting for discussion at the meeting or for the Agency Team to review and provide comments for use in preparing the Revised Final SARFFS. A complete and accurate delineation of ARARs is a critical component to the future evaluation of the success of the source area remedial action. Clear Creek agrees with ITSI Gilbane that Crane Co should complete this step through consultation with EPA and ADEQ. *Updated: The Agency Team has prepared comments on the Draft ARARs Table provided with the presentation materials for the 2/6/20213 Quarterly Technical Meeting. These comments are included with the technical memorandum transmitting this revised evaluation table to the RTC.*

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Maj-10	ITSI Gilbane	2.4.3	19			The statement that the existing network of extraction wells is serving as a hydraulic barrier is questionable. Please see the November 28, 2011, technical memo "Revised Technical Comments on Draft Subunit A Capture Zone Report, Phoenix-Goodyear Airport North Superfund Site, Goodyear, Arizona" (Reference: See #11 on 2011 Deliverables Table/#15 on 2012 Deliverables Table). Further, the agency comments regarding the Revised Draft Subunit A Capture Zone Report submitted on October 31, 2012, will be discussed during a conference call scheduled for December 13, 2012. This discussion (as well as subsequent written agency comments that will follow the call) should be used to inform the understanding of this section and overall hydraulic capture as discussed in the FFS.	The Crane Co. team respectfully disagrees that the hydraulic barrier created by the existing extraction well network is questionable. Rather, the evaluation of current field data demonstrates that the capture zone from these wells extends east just beyond Litchfield Road. In an effort to increase hydraulic capture of the Subunit A TCE plume along the Van Buren transect, Crane Co. proposed to install extraction well EA-09 north of Van Buren Street. A primary objective of extraction well EA-09 is to provide enhanced hydraulic control of Subunit A groundwater flow as it relates to the planned source area remediation. It is anticipated that the existing Subunit A MTS extraction well network (EA-01, EA-03, and PZ-01), along with the addition of new extraction well EA-09, will serve as an effective hydraulic barrier for any source area treatment amendment that is selected. It should be noted that the hydraulic barrier required to prevent down-gradient migration and enhance remediation amendment distribution only needs to be slightly larger than the footprint of the conceptual aerial extent of the source area treatment; therefore, the hydraulic barrier (for the purposes of the source area treatment) does not have to encompass the entire width of the Subunit A TCE plume along Van Buren Street (please see Figure 6 of the Final SARFFS for the aerial extent of the source area treatment).	Acceptable response with comment. Resolution of the adequacy of the capture of the Van Buren extraction well line is deferred to the Subunit A Capture Zone report and the evaluation of the performance of EA-09. Clear Creek agrees with the concerns raised by ITSI Gilbane regarding the extent of capture at Van Buren Street. Installation of new extraction well EA-09 is important to address the high concentrations of TCE observed north of Van Buren, but it is not a substitute for enhancement of the on-site hydraulic barrier to ensure complete capture at Van Buren Street, closest to the source area, through the rehabilitation or replacement of extraction well EA-04 as previously requested by EPA. *Updated: As discussed at the 2/6/2013 Quarterly Technical Meeting, a reference to the current status and findings of the Subunit A Capture Zone Report should be made as well as a notation that capture will be continually reviewed, especially after the installation of EA-09, and recommendations for changes made as appropriate.*
Maj-11	CH2M Hill	Section 3.2		8 through 11		There is inconsistency in the document with the injection well spacing's assumed for Alternatives 3 through 6. While the results of the Phase III Pilot Test were referenced as the basis for injection spacing (a 30-foot radius of influence (ROI) was achieved in Phase III), the injection spacing's for Alternatives 3 through 6 are 25 feet, 60 feet, 15 feet, and 60 feet, respectively. Please describe the reasoning for these differing injection spacing's. There also is inconsistency within the descriptions of each alternative with regard to injection ROI and spacing. For example, Section 3.2.5 states that for Alternative 4, the "nZVI dose was derived . . . within a 25-foot radius of the injection point," which is different from the 30-foot injection ROI achieved in the Phase III Pilot Study, and conflicts with the 60-foot injection spacing assumed for Alternative 4. Also, Section 3.2.6 states that "injection spacing would need to be 10 feet or less due to the injection characteristics of the ZVI particulate slurry," but the Alternative 5 design injection spacing is 15 feet. Finally, the text of Section 3.2.7 states that "each injection point will be spaced on 50-foot centers" vs. the 60-foot spacing indicated elsewhere for Alternative 6. Please explain or resolve these and other similar discrepancies.	The injection spacing for each of the alternatives was chosen based on the type of amendment, injection method, and Subunit A hydrogeology as outlined below: [SEE TABLE IN ORIGINAL 14 January 2013 RTC] A similar dosing method as was used for the Phase IV Pilot Test was assumed for Alternative 4, and because the pilot test yielded a radius of influence of 30 feet, that distance was also used for the conceptual design of the remedy as described in Section 3.2.5. This approach will be clarified in the text of Section 3.2.5. The language in 3.2.6 will be clarified to indicate that hydraulic fracturing would be used to improve the radius of influence to 15 feet. In Section 3.2.7, this typographic error will be correct to read 60-foot centers.	Acceptable Response.

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Maj-12	CH2M Hill, ITSI Gilbane	2.3 & 3.2				Section 2.3 states that the source area treatment covers and area of 350,000 square feet (sf). In Section 3.2, all the alternatives describe the source area as 250 feet wide by 700 feet long (175,000 sf). Please explain or resolve this discrepancy and make sure other calculations in the document use the correct assumption.	The area defined in Section 2.3 was from a previous iteration of the report and will be updated to 175,000 square feet.	Acceptable Response.
Maj-13	CH2M Hill	3.2.7, App D				While the text states that 290,000 lbs. of permanganate will be injected for Alternative 6, Appendix D (Table D6b) states that 488,060 lbs. will be injected. Please explain or resolve this discrepancy.	The mass listed in the Appendix D is correct and the text will be corrected.	Acceptable Response.
Maj-14	ITSI Gilbane	3.3.2				See ITSI Gilbane comment above (Maj-9) regarding the ARARs discussion/evaluation. That comment also applies to this section, where compliance with the ARARs should be presented for evaluation.	An evaluation of the proposed remediation alternatives relative to achieving the ARARs will be added to this section.	Acceptable response with comment. See evaluation of Maj-9. *Updated: The Agency Team has prepared comments on the Draft ARARs Table provided with the presentation materials for the 2/6/20213 Quarterly Technical Meeting. These comments are included with the technical memorandum transmitting this revised evaluation table to the RTC.*
Maj-15	EPA	3.3.2	40			The ARARs must be identified before any analysis of whether the alternatives meet them is conducted. Additionally, more information than is currently provided in the FFS may be necessary to determine whether a particular alternative meets the ARARs. For instance, the chemical-specific ARARs require trichloroethene (TCE) to be brought down to below the drinking water maximum contaminant level (MCL). The alternatives here are aimed at reducing mass, but not necessarily getting the TCE to below 5ppb. Elaboration on these alternatives as supplements to the current remedy would be helpful.	This comment is acknowledged, please see above.	*Accepted with Comment: See response regarding the Draft ARARs as noted in the evaluation to Comment Maj-14. Regarding the elaboration of the alternatives, it is understood that draft text to respond to this comment will be provided as discussed in the 2/6/2013 Quarterly Technical Meeting. The intent is to review and reach consensus on this revised text in advance of preparing the Revised Final SARFFS.*

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Maj-16	EPA	3.3.3	41-42		10	EPA has now developed and distributed a Methodology for carbon footprint analysis and a spreadsheet template for applying the methodology to a specific Site. Please see the links below and develop the analysis per EPA guidance. Questions on the use of the Methodology and Spreadsheets for Environmental Footprint Analysis (SEFA) - including scheduling of a Site-specific training workshop - can be directed to Karen Scheuerman of EPA Region 9. She can be reached via email at Scheuermann.Karen@epa.gov or via phone at (415) 972-3356. __**Resources:**__ **EPA's April 2012 Webinar: http://www.clu-in.org/live/archive/** (search for April 2012, then look for "Greener Cleanups - EPA's Methodology for Understanding and Reducing a Project's Environmental Footprint", 18 April 2012) **Fact Sheet for EPA's Footprinting Methodology:** http://clu-in.org/greenremediation/methodology/docs/GR_Overview_of_Footprint_Methodology_FS_3-29-12.pdf **EPA's Footprinting Methodology (full title: "Methodology for Understanding and Reducing a Project's Environmental Footprint"**, issued February 2012): http://www.clu-in.org/greenremediation/methodology/ The SEFA workbooks in template form (full name: "Spreadsheets for Environmental Footprint Analysis"): www.clu-in.org/greenremediation/methodology (scroll to bottom of web page)	A replacement carbon footprint analysis will be developed per EPA guidance as referenced in the above comment. The SARFFS report will be updated accordingly.	*Accepted with Comment: During the 2/6/2013 Quarterly Meeting, the Crane Team noted that draft text changes as a result of the Agency Team comments would be submitted for review in advance of the Revised final SARFFS. With this understanding, the Agency Team looks forward to reviewing the replacement carbon footprint analysis per the original comment in the next RTC in advance of receiving the Revised Final SARFFS.*

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Maj-17	CH2M Hill	App C4		---	---	The case studies provided in Appendix C describe issues with the implementation of nZVI that are not clearly addressed in the SARFFS: (a) Passivation of nZVI prior to injection due to mixing with oxygenated water occurred in 2 of the case studies. Has the potential issue of nZVI passivation <u>during</u> injection into an aerobic aquifer been accounted for in the design of Alternative 4? (b) For the case study employing pneumatic fracturing, "ZVI mass in excess of the contaminant stoichiometry was necessary to bring about significant abiotic reduction of CVOCs," and the study indicated that "dissolved-phase TCE was treated in the short-term, but sorbed TCE may gradually show up as dissolved-phase in the monitoring wells." As suggested in Major Comment No. 11 to the Draft SARFFS, excess contaminant mass will likely be released during jet-assisted injection and the nZVI stoichiometry calculations need to account for this additional mass in excess of the maximum dissolved-phase concentrations found in monitoring wells. Please provide information in the SARFFS on how this excess contaminant mass released during jet-assisted injection has been accounted for in the reagent mass calculations, or how the reagent demand from sulfate still dominates even when accounting for this excess contaminant mass.	In case (a) above, passivation occurred due to use of oxygenated water. The Phase IV Pilot Test used anaerobic water and thus avoided this problem, therefore, this method was assumed for use with alternatives in the SARFFS that include ZVI as a remediation amendment. In case (b) above, dissolved phase contaminant mass that may gradually show up in groundwater will be subject to ARD and macroscale ZVI in addition to nZVI. The electron donor concentration assumed for application of ARD is dosed to provide an equivalent or greater number of electrons to reduce electron acceptors similar to the nZVI dosage. Additionally, the ZVI dosage is based on the anticipated electron demand of the soil. This dosing strategy provides at least three times the number of electrons as was used during the Phase IV pilot test. This approach will be clarified in the text as necessary. Attached, please find an updated spreadsheet providing the Crane Co. team's response to minor comments (Attachment 1) on the Final SARFFS Report. In addition, Attachment 2 is a narrative and supporting data for site-specific analyses performed to evaluate the potential for permanganate to mobilize metals from site soils. This recently obtained information will be included in the next draft of the SARFFS report.	Acceptable Response.
Minor (Min-) Comments								
Min-1	EPA	1.2.2	2-5			The perchlorate history and context needs revision. This paragraph should explain the highest levels found at the Site historically and the current levels found. Context regarding perchlorate in Subunit C and its connection to Subunit A would be helpful.	Please see the response to Maj-7.	*Acceptable Response with Comment: Please see additional evaluation of Comments Maj-2 & Maj-7 above.*
Min-2	EPA	1.2.2	2-5			We need all the data this FFS considered, as well as the data the PRP decided <u>not</u> to use, so that we at EPA can draw our own conclusions - as can people who want to look at the Administrative Record.	This comment has been noted.	*Accepted with Comment: See Response to Comment Maj-2.*
Min-3	EPA	2.2	15-14			The selection of the RAOs for this FFS needs to be better explained. The document should explain why we need mass and contaminant concentration reductions.	Please see the response to Maj-6.	*Accepted with Comment: See Response to Comments Maj-2 and Maj-6.*

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Min-4	EPA	2.2.2	16			Throughout the document, but particularly in this section, "site" versus "facility" needs to be clarified.	This comment has been noted.	*Accepted with Comment: See response to Comment Maj-2. NOTE: The terms "facility" and "Site" should be used in a manner consistent with the Consent Decree directing this work.*
Min-5	EPA	2.2.3	16			Remedies are not selected through enforcement instruments but through agency decision documents. The PGA-North groundwater remedy was selected in the 1989 ROD, subsequent ESDs, and the Removal Action Memo for Perchlorate. The FFS must evaluate whether the ARARs that were established in those documents still apply and whether there are other ARARs relevant to the evaluated alternatives. These ARARs must include any new aspects that might arise from the considered alternatives so that the determination can be made as to whether those alternatives can meet ARARs, including chemical specific (e.g. perchlorate cleanup levels), action specific (e.g. for injection into the subsurface), and location-specific ARARs.	Please see the response to Maj-9 and -14.	*Acceptable Response with Comment: See evaluation provided to Comments Maj-9 and Maj-14.*
Min-6	EPA	2.2.4	16			The "primary remediation goals" for the Site are containment and aquifer restoration. After that, the methods used, or subgoals, could include reducing mass as ways to help us toward the primary ones.	This comment has been noted.	*Accepted with Comment: See Response to Comment Maj-2.*
Min-7	EPA	2.2.4	16			The FFS appears to be making an additional goal of containment within the source area. This should be discussed in the RAO section as well (potentially as an expansion of the containment RAO).	The RAOs will be updated as discussed in the response to Maj-5.	*Accepted with Comment: See Response to Comment Maj-2.*
Min-8	USACE	2.2.4	16			The quantification of the mass flux will be an important metric for the success of the source area treatment, but this measurement is difficult to make. Once the Subunit A extraction wells along/near Van Buren (EA-03, PZ-01, EA-04, and EA-09) are all in place, data from these wells will provide an excellent mechanism to monitor mass flux (with relative certainty of full capture). The quantification of mass flux must be determined before source area treatment is initiated, and future plans should address this requirement.	This comment has been noted. The design phase for the chosen remedy is anticipated to include an assessment of mass flux and fate and transport modeling to evaluate longevity of amendments.	Acceptable Response.

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Min-9	EPA	2.3	16-17			This section needs rewording. As it is, it appears to redefine the remedial goals away from containment and restoration. EPA has not made that determination, and the FFS does not support removal of the original RAOs. This section should clarify that the initial remedial goals remain in place while the goals set forth for this effort supplement the original ones.	Please see response to Maj-1, -5, and -6.	*Acceptable Response with Comment: See evaluation provided to Comments Maj-1, Maj-5, and Maj-6.*
Min-10	EPA	2.4.1	18			The status of the current remedy (pump and treat and SVE) in the source area must be explained explicitly. It is unclear from this section what parts of the original remedy are expected to remain in place while an alternative from the FFS is implemented.	The current status of the site groundwater remedy, including the pump and treat and SVE components, will be clarified in the section.	*Accepted with Comment: See Response to Comment Maj-2.*
Min-11	EPA	2.4.1	18			Dual phase extraction: Nothing is discussed with regard to perchlorate treatment in this section.	A discussion of dual phase extraction effectiveness on removing perchlorate will be added to this section.	*Accepted with Comment: See Response to Comment Maj-2.*
Min-12	EPA	2.4.1	18			Dual phase extraction: Air emissions treatment must be conducted pursuant to the selected ARARs, not a permit.	This comment has been noted.	*Accepted with Comment: See Response to Comment Maj-2.*
Min-13	EPA	2.4.1	18			Clarification: IWAS: IWAS should be defined.	This comment has been noted.	*Accepted with Comment: See Response to Comment Maj-2.*
Min-14	EPA	2.4.3	19			In the following sections (here in the second paragraph about active barrier systems) and in the following sections (here in the second paragraph about active barrier systems), it is stated that it has been determined that the source area is cut-off from the downgradient contamination. It should be clarified whether there is sufficient data to show that or whether more needs to be done to assess or accomplish that.	Please see the response to Maj-10.	*See RTC Eval Comment Maj-10.*
Min-15	USACE	2.4.5	20			The in-situ use of hydrogen peroxide is essentially always in the Fenton's reagent mode, not with ultraviolet (UV) light.	This comment has been noted. However, hydrogen peroxide is also used with ozone for application of advanced in -situ oxidation.	Acceptable Response.

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Min-16	EPA	2.4.6	21			Clarification: Clarify whether bioaugmentation testing "in the field" is not at this Site itself.	This statement referenced bioaugmentation test performed at other site. This will be clarified in the text.	*Acceptable Response with Comment: During the 2/6/2013 Quarterly Meeting, the Crane Team noted that draft text changes as a result of the Agency Team comments would be submitted for review in advance of the Revised final SARFFS. With this understanding, the Agency Team looks forward to reviewing the revised language per the original comment in the next RTC in advance of receiving the Revised Final SARFFS.*
Min-17	CH2M Hill				2	For Table 2 referenced in Section 2.4.8, please add explanation of how the use of micro-scale zero valent iron (ZVI) can lead to increases in arsenic. Why would the same issue with increased arsenic not apply for nano-scale ZVI (nZVI)?	An explanation of how dissolved arsenic concentrations can increase in the presence of nZVI and ZVI will be added to Section 2.4.4, and will be referenced in Table 2 as necessary.	Acceptable Response.
Min-18	EPA	3	23			Please clarify what it means that "the alternatives were approved, so they will not be screened."	A description of the screening process for choosing the remediation alternatives is provided in Section 2.4. This text will be revised to refer to this section.	*Acceptable Response with Comment: See Evaluation of Comment Min-16.*
Min-19	EPA	3	23			Clarification: at this stage in the process, EPA only evaluates the first 7 criteria. State and community acceptance are evaluated following the issuance of the Proposed Plan (unless we already have approval of the state).	This clarification will be added to the appropriate section.	*Acceptable Response with Comment: See Evaluation of Comment Min-16.*
Min-20	CH2M Hill				3	For Table 3 referenced in Section 3.2.1, under the Alternative 4 and 5 descriptions for Protection of Human Health and Environment, it states that the dissolution of iron hydroxides may result in the production of arsenic (As), hydrogen sulfide (H_2S), and methane (CH_4). Please provide a brief description of geochemical conditions under which iron hydroxides would dissolve (e.g., shift from anaerobic to aerobic conditions). Please also explain how the dissolution of iron hydroxides may result in the production of H_2S, and CH_4, as these are potential byproducts of ARD.	This description will be added to Section 2.4 as appropriate to the technology type, and references will be added to Table 3.	*Acceptable Response.*
Min-21	EPA	3.2.2	24			It must be made explicit whether the No Action Alternative here refers to true no action or continuation of the current remedy.	This comment has been noted. The baseline is assumed to be a continuation of the current groundwater remedy. This section will be updated to state this assumption.	*Accepted with Comment: See Response to Comment Maj-2.*

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Min-22	EPA	3.2.3	24-26			Assuming that the assumptions made for long-term monitoring are only for costing purposes, that needs to be made explicit. At this stage, no assurances should be made as to the frequency of monitoring (e.g., statements re 3 years of semi-annual monitoring).	This comment has been noted.	*Accepted with Comment: See Response to Comment Maj-2.*
Min-23	EPA	3.2.4	26			The last sentence at the bottom of this page refers to the initial Draft Subunit A Capture Zone Report dated September 23, 2011. This report has since been revised and resubmitted as a revised draft dated October 31, 2012 and is the subject of a conference call on December 13, 2012 to discuss general agency concerns about the report. This portion of the text should be revised to reflect the current status of this report.	Please see the response to Maj-10.	*See RTC Eval Comment Maj-10.*
Min-24	ITSI Gilbane				5,6,7	For Tables 5, 6, & 7 (as referenced in Sections 3.2.4 - 3.2.6), Alternatives 3, 4, and 5 have different radii of influence for injection; however, the proposed quantities for microbial culture and emulsion per injection are the same. These quantities are supposed to be calculated according to (1) the hydrogen demand of major electron acceptors and (2) the ratio between microbial culture and targeted groundwater volume for treatment per injection, and are expected to be different for these three alternatives.	The emulsion dosage and volume of bioaugmentation will be adjusted as necessary for each of the three alternatives; however, the total volume of the emulsion and bioaugmentation culture will not change because it is dependent on the volume and mass of contaminants of and within the treatment area, which do not change.	Acceptable Response.
Min-25	ITSI Gilbane				5, 6,7, 8	For Tables 5, 6, 7, & 8 (as referenced in Sections 3.2.4 - 3.2.7), for these alternatives, the locations for re-injections will be more than 10 percent of the original points. For instance, the typical lifetime in the subsurface for EVO is 3 to 5 years, and the persistence of permanganate in groundwater in this kind of environment is probably less than 5 years. It is very likely that as high as 50% of the locations might need re-injection.	The estimate in these tables is believed to be reasonable for the purpose of the SARFFS.	Acceptable response with comment. This issue could be addressed in the design phase and implementation of the remedy.

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Min-26	ITSI Gilbane	3.2.5	32		6	It is still not known how bioaugmentation will be conducted following ZVI/nZVI injection in this alternative. It is very likely that <u>at least two mobilizations</u> will be needed for a successful bioaugmentation at the Site. This will impact both schedule and cost. The nZVI/ZVI injection (especially nZVI) will result in high pH value in groundwater (higher than 10.8 in pH was observed in nearby monitoring well IW-01 during the Phase II nZVI Pilot Test), and volatile fatty acids resulting from the degradation of simultaneous injection of emulsified vegetable oil (EVO) will help buffer the pH in the groundwater. However, it will take time for these volatile fatty acids to form after injection of EVO. The optimal pH condition for microbial culture such as KB-1 (which Haley & Aldrich proposes to use) is between 6 and 8.5; therefore, it is expected that a couple of months or even several months will be needed before bioaugmentation is feasible, e.g. has measurable positive results. Please comment on this as well as on how this revised approach affects the SARFF ratings for this alternative.	A recent study (Battelle 2012) showed that bioaugmentation that is performed at the same time as electron donor injection can result in the same remediation timeframe as when bioaugmentation is performed separately. Some of the degrader microorganisms die off during the injection, but the lag time in regrowth of the microbial population is matched by the lag in waiting for the aquifer to become anoxic and reducing. At this Site, because the ARD is paired with nZVI and/or ZVI, reducing conditions are immediate and anaerobic water will be used the carrier fluid. Even if an additional mobilization is added for bioaugmentation, the relative evaluation of the alternative will likely not change due to the cost gap between Alternative 7 and the other alternatives.	Acceptable response with comment. Even though bioaugmentation could be done in the same time frame as electron donor injection, it is not known if bioaugmentation could be conducted at the same time as ZVI/nZVI and electron donor injection because of the potential high pH value caused by the ZVI/nZVI injection.
Min-27	EPA	3.2.5	29-32			The discussion claims that ZVI acts quickly, but there is no discussion of rebound. If there has been rebound, that should be discussed in this section.	This comment has been noted.	*Accepted with Comment: See Response to Comment Maj-2.*
Min-28	ITSI Gilbane	3.2.7	36			The discussion on the use of ISCO as an alternative should mention the potential impacts to the ion exchange resin if water treated with ISCO is extracted along the hydraulic barrier and run through the treatment system. Permanganate (KMnO4) will compete with the perchlorate with the resin and negatively impact the treatment efficiency of the ion exchange vessels. (It is noted that as selective resin is used at the site, and the concentrations of permanganate will be low when it reaches the Van Buren hydraulic barrier, the potential impact on the resin likely is small.)	This comment has been noted.	Response is indefinite. Revision of the narrative with respect to this comment is expected. See also the response to Min-29.
Min-29	USACE	3.2.7	36		8	The second injection of oxidant would likely be needed at more than 10% of the locations - as much as 30-40% is believed to be needed. The same may be true for the bioremediation options, as well.	The estimate in these tables is believed to be reasonable for the purpose of the SARFFS.	While we do not agree with the response, resolution of this does not affect the conclusions. The Agency Team will need to assure that reapplication of the selected amendment is conducted where needed based on monitoring results. We assume that this is an acceptable plan given the use of the Triad approach as discussed by the Crane Team.
Min-30	EPA	3.2.8	29-32			Clarify whether the thermal treatment alternative is implementable in light of the fact that all subsurface features, including wells, must be removed to conduct the alternative. Explain how levels would be monitored and residual contamination would be addressed.	This comment has been noted.	*Accepted with Comment: See Response to Comment Maj-2.*

United States Environmental Protection Agency

Revised Agency Evaluation Table to Response to Comments on Final SARFFS (New Evaluation Noted in RED ITALICIZED Text)

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Phoenix-Goodyear Airport North Superfund Site

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Min-31	EPA	3.3.1	39-40			Same as above (Min-21): Alternative 1 is described as absolutely no action. Please clarify.	Please see response to Min-21.	*Accepted with Comment: See Response to Comments Maj-2 and Min-21.*
Min-32	EPA	3.3.1	39-40			The alternatives that do not treat perchlorate could be argued to not meet ARARs. Explain how this is not the case.	We disagree and believe that the alternatives that cannot treat perchlorate do not meet RAO's and possibly ARARs, especially since according to Comment Maj-7, perchlorate is to be considered a contaminant of concern.	*Although the RTC begins with "We disagree," the full response seems to agree with EPA's comment by stating that not only may they not meet ARARs but they also do not meet RAOs.*
Min-33	ITSI Gilbane	3.3.1	39			The discussion of In-Well Air Stripping (IWAS) mentions the risk of spreading contaminants off site. However, the option calls for the use of IWAS in conjunction with a hydraulic barrier; if an effective hydraulic barrier is maintained, there should be negligible risk of off-site contamination.	This comment has been noted.	Response is indefinite. Revision of the narrative with respect to this comment is expected.
Min-34	EPA	3.3.1	39			For the Alternative 3 analysis, it's unclear how the short-term protectiveness is evaluated if there is potential to stall at vinyl chloride or mobilize arsenic.	This section will be clarified to indicate that mobilization of arsenic is possible using ARD, and that the potential to stall at vinyl chloride is not likely assuming bioaugmentation is successful.	*Acceptable Response with Comment: See Evaluation of Comment Min-16.*
Min-35	EPA	3.3.1	40			The protectiveness evaluation for Alternative 6 is unclear. The FFS states that the Alternative is "moderately protective," however it also refers to levels of exposure to workers.	Section 3.3.1 stated that there is a low level risk to treatment system workers. This is not inconsistent with being moderately protective.	*Acceptable Response.*
Min-36	ITSI Gilbane	3.3.3	39			At the end of the first paragraph, there is a reference to cost information provided in Table 10. Table 10 provides the sustainability evaluation. The cost information is provided in Table 11. Please revise accordingly.	This comment has been noted.	Response is indefinite. Revision of the narrative with respect to this comment is expected.
Min-37	EPA	3.3.3	40			Meeting RAOs as defined here is not the same as long-term effectiveness and permanence. Clarification is necessary.	This comment has been noted.	*Accepted with Comment: See Response to Comment Maj-2.*

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Min-38	ITSI Gilbane	3.3.1	40			The paragraph discussing Alternative 6 states that ISCO/hydraulic barrier would be moderately protective of human health and the environment. This seems a biased statement against ISCO.	Please clarify how this statement is biased against ISCO.	The bias is towards the handling of the Van Buren hydraulic barrier if it completely captures the permanganate solution and untreated source area perchlorate plume. The text stated "...permanganate could be persistent in the environment and lead to the need for strict migration control measures beyond the current hydraulic barrier system," which is likely overstated. This should not cause the ranking of Alternative 6 to be lower than Alternatives 3, 4, and 5 in terms of protectiveness of human health and the environment. In addition, the persistence of permanganate in the environment will be an advantage for ISCO treatment of TCE in the source area, since it will have longer contact time and permanganate will likely diffuse into the fine area. Many studies have shown that the increased metal concentrations after ISCO injection are transient in nature and will attenuate rapidly within a short distance and in time. The anaerobic water created by Alternatives 3, 4, or 5 will be persistent in the area between the treatment area and Van Buren hydraulic barrier.
Min-39	USACE	3.3.3	40			See general comment (Gen-3) above.	Please see response to Gen-3.	See evaluation of Gen-3 above.
Min-40	ITSI Gilbane	3.3.3	40			The list of alternatives that likely would be moderately to highly effective at permanent reduction of source area COCs should include Alternative 6.	This comment has been noted.	Response is indefinite. Revision of the narrative with respect to this comment is expected.
Min-41	EPA	3.3.3	42		10	The focus for the FFS analysis of alternatives is a nine criteria analysis. Sustainability is not one of the nine criteria, and the document should be clear regarding this issue.	This comment has been noted.	*Accepted with Comment: See Response to Comment Maj-2.*
Min-42	ITSI Gilbane	3.3.5	43			The text states "perchlorate degradation has been strongly related to methane generation . . . " In reality, perchlorate degradation generally is related to the denitrification process, not methanogenesis.	This comment has been noted.	Response is indefinite. Revision of the narrative with respect to this comment is expected.

United States Environmental Protection Agency

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Min-43	USACE	3.3.5	43			Perchlorate degradation is correlated with denitrification, not methane generation. It is readily degraded under anoxic conditions, but you don't need it so reducing so as to be methanogenic.	Please see response to Min-42.	Response is indefinite. Revision of the narrative with respect to this comment is expected.
Min-44	EPA	3.3.5	43-44			The criterion is short-term protectiveness, not effectiveness. The alternative discussions need to include protection of workers and others potentially exposed in the short term within this section.	Please see EPA Guidance stating that the criteria is called short term effectiveness. A few references to EPA guidance documents are provided below. - United States Environmental Protection Agency Office of Solid Waste and Emergency Response Directive No.: FS4 March 1990, and, - United Stated Environmental Protection Agency (USEPA), 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies under the Comprehensive Environmental Recovery and Liability Act. October.	Acceptable Response.
Min-45	ITSI Gilbane	3.3.5	44			The first paragraph states that Alternative 6 (ISCO) would only treat readily available contaminant mass because the aquifer would not be fully permeated, and that the injection process is time-intensive and dispersion of the permanganate is required for the solution to reach between injection points. If fracturing and pressure injection are used, similar to Alternatives 4 and 5, this would not be an issue and the permanganate would be more likely to get into zones of low porosity.	This alternative assumes that jet-assisted fracturing would be used as the injection method. We agree with this comment and will modify the text as appropriate.	Acceptable Response.
Min-46	USCE	3.3.5	44			The difficulty in "fully permeating the aquifer" would apply to the ARD amendments as well as the oxidants.	This comment has been noted.	Response is indefinite. Revision of the narrative with respect to this comment is expected. This is an example of a disadvantage being applied to one alterative but not to another alternative where the same disadvantage is present, which imparts bias on the evaluation.
Min-47	EPA	3.3.8	46			State acceptance is assessed following issuance of the proposed plan. It is often possible to gauge state acceptance at any point in remedial development, but if there has not been an opportunity for formal state comment, this section should be reworded to indicate that it will be assessed later. Note, "federal acceptance" isn't a criterion and should be deleted.	This comment has been noted.	*Accepted with Comment: See Response to Comment Maj-2.*
Min-48	EPA	3.3.9	46			Same as state acceptance above (Min-47).	This comment has been noted.	*Accepted with Comment: See Response to Comment Maj-2.*

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Min-49	EPA	3.4.1	47			No action is not protective of human health and the environment, nor does it comply with ARARs. ARARs require restoration of the aquifer to drinking water standards. Doing nothing, or even capturing the contamination at the end, is not in and of itself protective. At least institutional controls (ICs), which would be a remedial component, would be necessary to prevent exposure.	This comment has been noted.	*Accepted with Comment: See Response to Comment Maj-2.*
Min-50	USACE	3.4.3	48			The disadvantages for ARD should include the potential for biofouling wells.	This comment has been noted.	Response is indefinite. Revision of the narrative with respect to this comment is expected. This is an example of a disadvantage being applied to one alterative but not to another alternative where the same disadvantage is present, which imparts bias on the evaluation.
Min-51	ITSI Gilbane	3.4.4	48			This section states that Alternative 4, nZVI-ZVI plus ARD plus hydraulic barrier, has been bench and pilot tested. The use of nZVI and ZVI have been tested independently; however, it is possible that the use of both together, depending on the injection configuration, could cause the fractures to clog up from the ZVI.	The larger grain size of the ZVI would serve to prop the fractures open, not clog them up.	Acceptable Response.
Min-52	ITSI Gilbane	3.4.4	48			The text states "The high activity of the nZVI destroys both perchlorate and TCE upon contact." Various studies have shown that nZVI has limited direct impact on perchlorate degradation, though it will facilitate the bioremediation of perchlorate in groundwater.	This comment has been noted.	Response is indefinite. Revision of the narrative with respect to this comment is expected.
Min-53	USACE	3.4.4	49			Alternative 4 has the third highest cost, not the fifth highest. (Note that Table 11 shows a range of costs for the in-situ thermal alternative that is not -30/+50% - more like -50/+100% - this should be corrected).	This comment has been noted. The range in cost for the thermal alternative will be reviewed and adjusted as necessary.	Acceptable Response.
Min-54	ITSI Gilbane	3.4.4	49			It is true that the ZVI will have better longevity in the source zone, but its radius of influence (ROI) will likely be smaller than that of the nZVI.	This comment has been noted. The distribution of ZVI will be limited to the extent of the fractures formed during injection.	Acceptable Response.
Min-55	ITSI Gilbane	3.4.5	50			The cost of hydraulic fracturing and injection is considered a disadvantage for Alternative 5 but not for the other alternatives that rely on this. This should be considered evenly for all technologies, as applicable.	Hydraulic fracturing is a different method than jet- assisted injection. The process of hydraulic fracturing is much lower pressure and requires a specialized tooling to initiate a notch in the formation to begin propagation of fractures. This process is quite different from jet-assisted injection and this will be explained in the text.	Acceptable Response.

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Min-56	ITSI Gilbane	3.4.6	50			The SARFFS lists as a disadvantage of Alternative 6 that chromium may be converted from trivalent chromium (Cr^{3+}) to hexavalent chromium (Cr^{6+}) from permanganate, thereby increasing its mobility and toxicity. However, Cr6+ would be likely to reduce back to Cr3+ as it is mixed with untreated aquifer water.	This comment has been noted.	Response is indefinite. Revision of the narrative with respect to this comment is expected.
Min-57	ITSI Gilbane	3.4.6	50			The SARFFS lists as a disadvantage of Alternative 6 that it may result in incomplete treatment in the MDWSA. This same argument also can be made about Alternatives 4 and 5. If the injections are done correctly and adequate data are collected regarding fracture patterns and the ROI of injectate, then Alternatives 4, 5, and 6 could all be effective.	The difference between Alternative 6, and Alternatives 4 and 5 is that the permanganate must come in contact with the target chemical and that it is not effective in treating perchlorate. Therefore, incomplete treatment of the MDSWA would result from application of Alternative 6.	Response to this comment is accepted. W e agree that the main difference is the effectiveness in treating perchlorate. For any injected media, it must come in contact with the target chemical in order to be effective in remediation. There is no difference between alternatives 4, 5, and 6 in this regard.
Min-58	USACE	3.4.7	51			Perchlorate would be driven ahead of a steam front, if steam was a component of the in-situ thermal treatment.	This comment has been noted.	Response is indefinite. Revision of the narrative with respect to this comment is expected.
Min-59	EPA	3.4.7	51			This is the only alternative that mentions potential rebound. Clarify whether the other alternatives have that potential as well.	This comment has been noted.	*Accepted with Comment: See Response to Comment Maj-2.*
Min-60	ITSI Gilbane	Ref	52			The Final Source Areas, Soil, and Facility Structures Investigation Report listed as Reference 8 was supplemented by an additional Responsiveness Summary dated October 26, 2011, which should be listed as a reference, since approval of the Final SASFS Report was not provided until this Responsiveness Summary was approved.	A reference to the additional Responsiveness Summary will be added to the text and references of the SARFFS report.	Acceptable Response.
Editorial (Edit-) Comments								
Edit-1	ITSI Gilbane	3.3.1	40			The text for Alternatives 4 & 5 is included in the text for Alternative 3. To make this information more reader-friendly regarding discussion of all alternatives in this section, it is recommended that the text on Alternatives 4 & 5 be moved to a new paragraph.	This comment has been noted.	Response is indefinite. Revision of the narrative with respect to this comment is expected.

ATTACHMENT 2

Support Document for Agency Team Evaluation of 2/1/2013 Draft ARARS for SARFFS
Permits and Permit "Equivalency" Processes for
CERCLA On-site Response Actions
OSWER Directive 9355.7-03
February 19, 1992
PGA North

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

FEB 19 1992

OFFICE OF
SOLID WASTE AND EMERGENCY RESPONSE

OSWER Directive 9355.7-03

MEMORANDUM

SUBJECT: Permits and Permit "Equivalency" Processes for CERCLA On-site Response Actions

FROM: Henry L. Longest II, Director /s/
Office of Emergency and Remedial Response

TO: Director, Waste Management Division
Regions I, IV, V, VII, and VIII
Director, Emergency and Remedial Response Division
Region II
Director, Hazardous Waste Management Division
Region X

PURPOSE

The purpose of this directive is to clarify the Environmental Protection Agency (EPA) policy with respect to attaining permits for activities at CERCLA sites. CERCLA response actions are exempted by law from the requirement to obtain Federal, State or local permits related to any activities conducted completely on-site. It is our policy to assure all activities conducted on sites are protective of human health and the environment. It is not Agency policy to allow surrogate or permit equivalency procedures to impact the progress or cost of CERCLA site remediation in any respect.

BACKGROUND

In implementing remedial actions, EPA has consistently taken the position that the acquisition of permits is not required for on-site remedial actions. However, this does not remove the requirement to meet (or waive) the substantive provisions of permitting regulations that are applicable or relevant and appropriate requirements (ARARs). (For further discussion on ARARs in general, see the attachment to this directive. For definitions of "substantive" and "administrative," see 55 FR 8756-57 and the CERCLA Compliance with Other Laws Manual, Part I, pages 1-11-12.) The proposed and final 1982 National Oil and

Hazardous Substances Pollution Contingency Plan (NCP) made no mention of the permit issue. However, EPA addressed the issue in a memorandum entitled "CERCLA Compliance with Other Environmental Statutes" which was attached as an appendix to the proposed 1985 NCP (50 FR 5928, February 12, 1985). The memorandum stated:

> "CERCLA procedural and administrative requirements will be modified to provide safeguards similar to those provided under other laws. Application for and receipt of permits is not required for on-site response actions taken under the Fund-financed or enforcement authorities of CERCLA."

EPA determined in the final rule [1985 NCP section 300.68(a)(3)] that "Federal, State, and local permits are not required for Fund-financed action or remedial actions taken pursuant to Federal action under section 106 of CERCLA." The 1986 amendments to CERCLA codified section 300.68(a)(3) of the 1985 NCP with a statutory provision, section 121(e)(1). CERCLA section 121(e)(1) provides that no Federal, State, or local permit shall be required for the portion of any removal or remedial action conducted entirely <u>on-site</u>, where such remedial action is selected and carried out in compliance with section 121.

The 1990 NCP [section 300.400(e)(1)] implements this permit exemption for "on-site" actions, defining "on-site" as "the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action." The preamble to the NCP (at 55 FR 8689, March 8, 1990) explains that "areal" refers both to the surface areas and the air above the site. EPA policy further defines "on-site" to include the soil and the groundwater plume that are to be remediated. On-site remedial actions may involve limited areas of noncontaminated land; for instance, an on-site treatment plant may need to be located above the plume or simply outside of the waste area itself.

As provided in NCP section 300.400(e)(1), response actions covered by CERCLA section.121(e)(1) include those conducted pursuant to CERCLA sections 104, 106, 120, 121, and 122. Thus response actions conducted by a lead agency, or by a potentially responsible party or other person under an order or consent decree with EPA, are covered under the ambit of CERCLA section 121(e)(1). Response actions by a lead agency include those response actions implemented by EPA, the Coast Guard, or another Federal agency. They also include response actions implemented by a State or political subdivision operating pursuant to a contract or cooperative agreement executed pursuant to CERCLA section 104(d)(1), under which EPA selects (or must approve) the remedy. Hereafter, the discussion concerning lead agencies should be understood to include, where appropriate, potentially responsible parties or other persons acting under CERCLA section 106.

DISCUSSION

While permits may not be required for CERCLA on-site response actions, some permitting authorities have attempted to require lead agency participation in a process that is "equivalent" to a permitting process in order to satisfy the authority's concern that there will be compliance with ARARs. In effect, they argue that participation in a permit-like process is necessary to identify the substantive provisions of permitting regulations.

Under a permit "equivalency" process, the lead agency is asked to participate in a process that an applicant would pursue to secure a permit, except that most fees and public hearing requirements are normally waived. The permit "equivalency" process itself has caused delay and cost increases in some response actions. The process holds the potential for further delays and cost increases due to often lengthy review of documents submitted to the permitting authority as if a permit were actually required, and due to the attachment of non-ARAR conditions by the permitting authority to the permit "equivalency." It also suggests, incorrectly, that the approval of a permitting authority is required before a CERCLA action may proceed or before an ARARs determination may be made with respect to the permitting regulations.

Unfortunately, some lead agencies have acquiesced to participation in such "equivalency" processes. Such acquiescence has been rationalized by the fact that it is particularly difficult to determine compliance with the substantive requirements of permitting programs, where levels are set on a site-specific basis, e.g., such as based upon the equipment provided by the remedial action contractor, or as would normally be set in a permit or in the Record of Decision (ROD) at Superfund sites. In some cases, lead agencies have agreed to participate in a permit "equivalency" process, although both the lead agency and the permitting authority have acknowledged the applicability of CERCLA section 121(e)(1).

EPA has consistently rejected the notion that CERCLA response actions are subject to such processes (see Background discussion above). The NCP, while acknowledging the need for coordination and consultation with other agencies, notes (at 55

FR 8756-7, March 8, 1990) that CERCLA section 121(e))(1) and other CERCLA provisions:

> "...reflect Congress' judgment that CERCLA actions should not be delayed by time-consuming and duplicative administrative requirements such as permitting, although remedies should achieve the substantive standards of applicable or relevant and appropriate laws... EPA's approach is wholly consistent with the overall goal of the Superfund program, to achieve expeditious cleanups, and reflects an understanding of the uniqueness of the CERCLA program, which impacts more than one medium (and thus overlaps with a number of other regulatory and statutory programs). Accordingly, it would be inappropriate to subject CERCLA response actions to the multitude of administrative requirements of other Federal and State offices and agencies.
>
> At the same time, EPA recognizes the benefits of consultation, reporting, etc. To some degree, these functions are accomplished through the State involvement and public participation requirements in the NCP. In addition, EPA has already strongly recommended that its Regional offices (and States when they are the lead agency) establish procedures, protocols or memoranda of understanding that, while not recreating the administrative and procedural aspects of a permit, will ensure early and continuous consultation and coordination with other EPA programs and other agencies. CERCLA Compliance with Other Laws Manual, [Part I], OSWER Directive No. 9234.1-01 (August 8, 1988). In working with States, EPA generally will coordinate and consult with the State Superfund office. That State Superfund office should distribute to or obtain necessary information from other State offices interested in activities at Superfund sites.
>
> The basis for this recommendation is a recognition that such coordination and consultation is often useful to determine how substantive requirements implemented under other EPA programs and by other agencies should be applied to a Superfund action. For example, although the Superfund office will make the final decision on using ARARs, a water office may provide information helpful in determining ARARs when a surface water discharge is part of the Superfund remedy.
>
> EPA also recognizes the importance of providing information to other programs and agencies that maintain environmental data bases. This is particularly true where the remedy includes releases of substances into the air or water and

the extent of such releases is integral for air and water programs to maintain accurate information on ambient air and surface water quality in order to set statutorily-specified standards."

IMPLEMENTATION

There are several possible ways to alleviate the delays and cost increases caused by a permit "equivalency" process. First, lead agencies can refuse to participate in this process, based on the fact that actual permits are not required under CERCLA section 121(e)(1), and procedural requirements are not ARARs under CERCLA section 121(d)(2) and the NCP.

Alternatively, and preferably, the lead agency could actively consult on a regular and frequent basis with the permitting authority, in situations where the lead agency deems it helpful to hasten ARARs identification. To facilitate such consultation, the lead agency should provide copies of the submittals of the design contractor and remedial action contractor in a timely manner to the permitting authority whose ARARs are the subject of the submittals. The NCP preamble explains (at 55 FR 8757, March 8, 1990) that if EPA is the lead agency, the coordination and consultation with State permitting authorities will generally be conducted through a single State office. Support Agency Cooperative Agreements, Superfund Memoranda of Agreement, or other protocols may be appropriate vehicles to establish specific time limits for the permitting authority to provide technical assistance in the evaluation of site-specific ARARs.

However, any such agreement should be based on the understanding that a procedural "permit" or permit equivalency approval is not required, but that the lead agency is participating in the process in order to facilitate coordination and consultation with the permitting authority. In some instances, because of the need to complete a response action and to avoid delays and cost increases, the lead agency may decide to terminate the consultation process. Nevertheless, this process should result in the lead agency's designing the remedy to meet all of the substantive requirements of the permitting regulations that are ARARs.

NOTE: The above policies and procedures are intended solely as guidance to EPA employees. They do not constitute rulemaking by the Agency, and may not be relied on to create a right or benefit, substantive or procedural, enforceable at law or in equity by any other person. EPA may take action that is at variance with the policies and procedures in this directive.

Attachment

Attachment

Discussion on ARARs

CERCLA section 121(d)(2)(A) and NCP section 300.430(f)(1)(i)(A) require EPA to select remedies that meet or waive certain Federal or State ARARs. ARARS are defined in the NCP at section 300.5 under the rubrics of "applicable requirements" and "relevant and appropriate requirements." For guidance on ARARs identification, see NCP sections 300.400(g); 300.430(e)(2); 300.515(d)(1) and (3) and (h)(2); CERCLA Compliance with Other Laws Manual, Parts I and II, OSWER Directives No. 9234.1-01 and -02 (August 8, 1988 and August 1989). The NCP does not require the concurrence of States or other Federal agencies (or other EPA program offices) on the Superfund Program's determination as to which standards are ARARs, although consultation with the appropriate State or Federal agency is required.

NCP section 300.435(b)(2) provides that once ARARs are selected, it becomes the responsibility of the lead agency during the Remedial Design (RD) and Remedial Action (RA) to ensure that all Federal and State ARARs identified in the ROD are met. In accordance with CERCLA section 121(d)(4) and NCP section 300.430(f)(1)(ii)(C), EPA may select a remedial action that does not meet an ARAR under any one of 6 waiver circumstances. If waivers from any ARARs are involved, the lead agency is responsible for ensuring that the conditions of the waivers are met. Pursuant to CERCLA section 121(f)(1), States must be provided an opportunity to comment on proposed ARARs waivers and may challenge ARARs waivers, as provided in CERCLA section 121(f)(2)and(3).

Remedial actions must comply with those requirements that are determined to be ARARs at the time of ROD signature. NCP section 300.430(f)(1)(ii)(B), in effect, "freezes" ARARs when the ROD is signed unless compliance with newly promulgated or modified requirements is necessary to ensure the protectiveness of the remedy. If ARARs were not frozen at this point, promulgation of a new or modified requirement could result in a reconsideration of the remedy and a restart of the lengthy design process, even if protectiveness were not compromised. This lack of certainty would adversely affect the operation of the CERCLA program, would be inconsistent with Congress' mandate to expeditiously clean up sites, and could adversely affect negotiations with potentially responsible parties.

As a general policy, EPA considers newly-promulgated requirements or other information as part of the review conducted at least every five years, under CERCLA section 121(c), for sites where hazardous substances remain on-site. The review requires EPA to assure that human health and the environment are being protected by the remedial action. Hence, the remedy should be examined in light of any new standards that would be applicable or relevant and appropriate to the circumstances at the site and in light of any other pertinent new information to ensure that the remedy is still protective. However, if such information comes to light at times other than at the five-year reviews, EPA will consider the necessity of acting to modify the remedy at such times.

After the ROD is signed, new information may be generated during the RD/RA process that could affect the remedy selected in the ROD. Such new information may result in "nonsignificant," "significant," or "fundamental" changes to the remedy. Nonsignificant changes are minor changes that usually arise during design and construction, when modifications are made to the functional specifications of the remedy to optimize performance and minimize cost. This may result in minor changes to the type and/or cost of materials, equipment, facilities, services and supplies used to implement the remedy. The lead agency need not prepare an explanation of significant differences for minor changes. These changes should be documented in the post-ROD file, such as the RD/RA case file. Significant changes to a remedy are generally incremental changes to a component of a remedy that do not fundamentally alter the overall remedial approach. The lead agency would need to publish in a local newspaper an explanation of significant differences announcing such changes. On the other hand, if the action, decree, or settlement fundamentally alters the ROD in such manner that the proposed action, with respect to scope, performance, or cost, is no longer reflective of the selected remedy in the ROD, the lead agency will issue a notice of availability and brief description of the proposed amendment to the ROD in a local newspaper in order to facilitate public comment. Proposed ROD amendments should identify new requirements that are ARARs and whether they will be met or waived.

For more guidance on responding to post-ROD information, see "Guide to Addressing Pre-ROD and Post-ROD Changes," Publication No. 9355.3-02FS-4 (April 1991), and "ARARs Q's & A's: General Policy, RCRA, CWA, SDWA, Post-ROD information, and Contingent Waivers," Publication No. 9234.2-0l/FS-A (June 1991), Questions 14-16.

To:	Catherine Brown, Remedial Project Manager, EPA Region 9
From:	Ailiang Gu, RG, PhD, Senior Hydrogeologist, ITSI Gilbane/Tempe Douglas Fisher, P.E., Senior Engineer, ITSI Gilbane/Tempe Nancy Nesky, P. E., Senior Project Manager, ITSI Gilbane/Tempe
Date:	January 28, 2013
Subject:	Revision 2 - Agency Evaluation and Comments to Source Area Remediation Focused Feasibility Study Report (SARFFS) Response to 14 December 2012 EPA Comments, Phoenix-Goodyear Airport North Superfund Site, Goodyear, Arizona
Contract /TO:	EP-S9-08-03/ TO 0004 **ITSI DCN:** 07163.0005.0383

ITSI Gilbane Company (ITSI Gilbane), on behalf of the U.S. Environmental Protection Agency (EPA), has reviewed the document titled Source Area Remediation Focused Feasibility Study Report (SARFFS) Response to 14 December 2012 EPA Comments, *Phoenix-Goodyear Airport North Superfund Site*. The document was prepared and submitted by Haley & Aldrich on January 14, 2013, on behalf of Crane Co.

It is understood that many of the responses provided will be discussed and resolved at the February 6, 2013, PGA North Quarterly Technical Meeting; however, the attached Agency Evaluation Table to Response to Comments (RTC) provides a summary of the Agency Team's evaluation of the responses provided. Mr. Dave Becker, US Army Corps of Engineers, provided his evaluation to the response to comments (RTC) by email dated January 24, 2013. The Arizona Department of Environmental Quality indicated their acceptance of the RTC by email dated January 25, 2013 (attached). The attached Agency Evaluation of RTC Table – Revision 2 includes comments submitted by Mr. Tom Suriano, Clear Creek Associates, via email dated January 28, 2013 (attached). It is understood that EPA will update the attached table to include EPA's evaluation of the RTC and issue Agency Evaluation of RTC Table – Revision 3.

Of particular note are the following two items:

1. Clarification of the "No Action" alternative description. The Agency Team understands this alternative to be a continuation of the existing remedies for both soil and groundwater.
2. The January 14, 2013 Response to Agency comments on behalf of Crane Co. includes as an attachment a tech memo titled, *Results of In-Situ Chemical Oxidation Screening Evaluation from Soils Collected During the Drilling of Monitoring Well EPA-MW-28C*. EPA was not informed of this bench test being conducted which raises concerns regarding other testing that may have been conducted that revealed different results. EPA is requesting that information regarding all such testing conducted for the Site be provided to EPA. Additionally, because EPA did not have prior information regarding this bench testing and did not review or approve any associated QA/QC for it, there are uncertainties about how the testing was done and therefore limitations on the use of the results.

A schedule for finalization of the SARFFS will be discussed at the February 6, 2013 meeting.

Please contact Ailiang Gu at 480-706-6488, ext. 4722 (agu@itsi.com), or Nancy Nesky at 480-706-6488, ext. 4712 (nnesky@itsi.com), with any questions about this technical memorandum.

Attachments (2):

1. Agency Evaluation Table to Responses to Comments on Final SARFFS
2. Arizona Department of Environmental Quality Comments to RTC on SARFFS (January 28, 2013)
3. Clear Creek Associates Comments on RTC to SARFFS (January 28, 2013)

cc: ITSI Gilbane Project File (electronic copy)

ATTACHMENT 1

Agency Team Evaluation Table (Revision 2) to
SARFFS Response to 14 December 2012 Comments From EPA
January 14, 2013
PGA North

Agency Evaluation Table to Response to Comments on Final SARFFS (Revision 2 - DRAFT)

Report Titled, "Source Area Remediation Focused Feasibility Study Report (Final SARFFS Report) Response to 14 December 2012 Comments, Phoenix-Goodyear Airport North Superfund Site, Goodyear, Arizona," Submitted by Haley & Aldrich on 14 January 2013

Phoenix-Goodyear Airport North Superfund Site

Comment Number	Reviewer(s)	Section(s)	Page(s)	Figure(s)	Table(s)	Comment from Agency Team	Crane Team's Response to Comment	Agency Team's Evaluation of Response to Comment
General (Gen-) Comments								
Gen-1	ITSI Gilbane					The SARFFS report is strongly biased toward the anaerobic reductive dechlorination (ARD) with zero valent iron/nano-scale zero valent iron (ZVI/nZVI) alternative and ARD with ZVI when discussing the impact of the remedy on groundwater quality. The report still overstates the impact of ISCO using permanganate on downgradient groundwater and the treatment system (precipitation of manganese oxide, carbonate, persistence of permanganate, chromium mobilization, etc.), while it understates the impact of ARD (potential arsenic mobilization, bio-fouling of injection wells and extraction wells).	The Crane Co. team does not believe the SARFFS report to be strongly biased; however, the report will be reviewed and the language adjusted as appropriate. We agree that both the ZVI/nZVI + ARD and in-situ oxidation (ISCO) alternatives may have impacts to groundwater quality that are similar in magnitude. The major difference between the two remedies remains that the remediation alternative including ARD will treat perchlorate, one of the two contaminants of concern, and the ISCO alternative will not.	Response noted. The perceived bias noted by the Agency Team can be discussed during the February 6, 2013, Quarterly Technical Meeting. Resolution of this comment is expected at that time. Crane Co.'s response indicates that they will review the draft SARFFS report and adjust language to address perceived bias in its evaluation; however, Crane Co continues on to highlight the potential for the ZVI and ARD approach to address perchlorate. Clear Creek notes that the magnitude of perchlorate impacts in the source area is far less than the magnitude of TCE impacts in the source area. Accordingly, the primary consideration should be the remedial alternatives potential effectiveness in meeting remedial objectives for TCE. Additionally, for nZVI alternatives that rely on jet assisted injection, field evidence is currently lacking to demonstrate this techniques' effectiveness to emplace a nZVI barrier of sufficient thickness throughout the targeted depth interval. This uncertainty is understated in the draft SARFFS. Finally, the uncertainty associated with the sustainability of the chloroethene degrading microorganisms (as recognized in Crane Co.'s response to General Comment No. 5 [CH2M Hill]) is also understated in the draft SARFFS.

Agency Evaluation Table to Response to Comments on Final SARFFS (Revision 2 - DRAFT)

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Phoenix-Goodyear Airport North Superfund Site

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Gen-2	ITSI Gilbane					The text states that the 12 proposed new monitor wells will be installed in a period of 3 to 4 years. It seems to be more beneficial to install all the monitor wells before the initiation of the remediation to better define the targeted treatment zone and better characterize Subunit A in the targeted treatment zone. This is especially true for the eight proposed monitor wells that are outside the active injection area.	For the SARFFS remediation alternatives that include jet-assisted injection (ARD, ZVI/nZVI+ARD, and ISCO), installation of monitoring wells prior to injection may cause damage, if not complete failure of the monitor wells. Determination of monitoring well locations for these alternatives is intended to be part of the iterative real-time execution of a Triad approach. The Triad approach would include definition of the treatment zone through measurement of trichloroethene (TCE), daughter products, and perchlorate concentrations in hydropunch samples collected during drilling of injection well boreholes in an offset grid pattern. The locations and screen intervals for the injection and monitoring wells would be determined at this time and in accordance with the depth of the bulk of the contaminant mass. The final decision process for determination of location and depths of the injection and monitoring wells will be drafted during the design phase of the remedy and will be subject to approval from the EPA and other stakeholders at that time.	We agree that the locations of the monitoring wells should be mainly based on Triad approach; however, the proposed monitoring wells outside the target treatment zone will not likely be impacted by the jet-assisted injection. Installation of those monitoring wells will help to define the targeted treatment zone and potentially result in cost saving with a smaller treatment zone. We can discuss it during the February 2013 quarterly meeting. We agree that this item should be addressed in the design phase of the proposed remedy.
Gen-3	USACE					It was surprising and disappointing that the focused feasibility study still appears to provide a biased presentation, particularly of the in-situ chemical oxidation (ISCO) alternative. The impacts related to the potential mobilization of chromium, migration of permanganate, and the impact on the main treatment system (MTS) from residual permanganate is somewhat overstated. This is particularly true relative to the presentation of the potential mobilization of arsenic, impacts of biofouling on the wells and plant, and the migration of anaerobic water for the bioremediation alternatives. The use of the ARD with ZVI/nZVI is supported, but the key difference is the treatment of perchlorate. The ground water extraction system is an appropriate remedy for a highly mobile constituent like perchlorate; however, the recent increase of perchlorate concentration to over 50 ug/L in MW-04 is significant, and it does seem that the Agency Team is anxious to treat perchlorate beyond the current ground water extraction.	The SARFFS report will be reviewed and the language adjusted as appropriate. Although both the ZVI/nZVI+ARD and ISCO alternatives may have impacts to groundwater quality and aboveground and subsurface groundwater treatment system infrastructure that are similar in magnitude, the Crane Co. team agrees that the major difference between the two remedies is that the ZVI/nZVI+ARD alternative will treat perchlorate and ISCO alternative will not.	Without seeing the revised language, it is difficult to accept this comment as provided; however, the perceived bias noted by the Agency Team can be discussed during the February 6, 2013, Quarterly Technical Meeting. Resolution of this comment is expected at that time.
Gen-4	ADEQ					As noted in the Monthly PM Call held with the PGA North Team on December 6, 2012, the Arizona Department of Environmental Quality (ADEQ) comments provided in Attachment 1 of this document are items that should be considered moving forward in this phase of the project. To be complete, these comments are provided here by reference but, as noted by Travis Barnum during the PM Call, these comments do not require a written response in the Responsiveness Summary.	The ADEQ's comments are acknowledged and will be considered as we move forward to the design phase of the project.	Acceptable Response.

Agency Evaluation Table to Response to Comments on Final SARFFS (Revision 2 - DRAFT)

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Phoenix-Goodyear Airport North Superfund Site

Comment Number	Reviewer(s)	Section(s)	Page(s)	Figure(s)	Table(s)	Comment from Agency Team	Crane Team's Response to Comment	Agency Team's Evaluation of Response to Comment
Gen-5	CH2M Hill	3.3 and 3.4			3	The draft FSA strongly advocates the anaerobic reductive dechlorination (ARD) with macro-scale zero-valent iron (ZVI)/nano-scale ZVI (nZVI) alternative described in Alternative 4. Comparative analysis still does not seem to present an objective and balanced view of the benefits and drawbacks of the proposed alternatives. For example, mobilization of arsenic and the production of an anaerobic plume through the use of nZVI and ZVI are potential disadvantages that are of equal significance as the potential for In-Situ Chemical Oxidation (ISCO) to result in permanganate persistence in the aquifer, yet these alternatives are described with differing potential for success. Additionally, perchlorate will not degrade with nZVI or ZVI without the presence of active bioremediation as a polishing step. Currently, it is not known if an active biological population will be sustainable at the project site. This is an important understanding to the use of the nZVI/ZVI technologies, and as such, these technologies should not rank higher than the ISCO alternative for Long-Term Effectiveness and Permanence. ISCO should rank very similarly with any ZVI/nZVI technologies, and both should be a contingent consideration for site use if the eventual preferred alternative does not meet the necessary remedial criteria and performance measures to be established in the remedial design/remedial action process.	The SARFFS report will be reviewed and the language adjusted as appropriate. The Crane Co. team agrees that the magnitude of impacts to groundwater quality and aboveground and subsurface groundwater treatment system infrastructure from both the ZVI/nZVI+ARD and ISCO alternatives may be similar, and that the major difference between the two remedies is that the ZVI/nZVI+ARD alternative will treat perchlorate by using the active bioremediation as a polishing step and the ISCO alternative cannot. The fact gives the ZVI/nZVI+ARD a distinct advantage in Long-Term Effectiveness and Permanence when compared to ISCO alternative. There are many bioremediation projects that demonstrate successful development of anaerobic and reducing conditions, and growth of degrader populations resulting from the injection of an electron donor into groundwater. The Crane Co. team acknowledges that at this time the sustainability of chloroethene degrading microorganisms in Subunit A is unproven. However, perchlorate biodegradation is facilitated by microorganisms that are ubiquitous in aquifers [Logan, B.E. (2001) Assessing the Outlook for Perchlorate Remediation. Environ. Sci. & Tech., 35, 482]. The conditions at PGA-North are unlikely to prevent growth of the indigenous microbial population resulting in the consumption of oxygen, and conversion to anaerobic and reducing conditions, and that those conditions can be maintained in the presence of excess electron donor. Finally, the Crane Co. team believes that the groundwater remediation alternative chosen as a contingency need not be considered equivalent to the recommended alternative.	Acceptable Response. The potential advantage for ISCO to diffuse into fine grained and no flow zones, thereby reducing the potential for back diffusion of TCE over time, is understated in the draft SARFFS. See also Comments to Gen-1.
Major (Maj-) Comments								
Maj-1	EPA	1.1	1			This section should discuss the 1989 Record of Decision (ROD) and PGA-North remedy in place. This is necessary for context that this is for an amendment to that remedy decision in order to speed reduction in persistent source area contamination despite 20 years of treatment rather than a replacement for the remedy.	The comment is noted and a discussion of the 1989 ROD and the PGA-North remedy in-place will be incorporated into the Revised Final SARFFS Report as requested.	Acceptable Response.
Maj-2	EPA	1.2.2	2-5			The Site history requires significant revision.	The comment is noted and Section 1.2.2 will revised to include additional information about the Site History.	

Agency Evaluation Table to Response to Comments on Final SARFFS (Revision 2 - DRAFT)

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Phoenix-Goodyear Airport North Superfund Site

Comment Number	Reviewer(s)	Section(s)	Page(s)	Figure(s)	Table(s)	Comment from Agency Team	Crane Team's Response to Comment	Agency Team's Evaluation of Response to Comment
Maj-3	EPA	1.2.2	2-5			Significant Site information has been amassed since the 1989 remedial investigation/feasibility study (RI/FS) about Site soils, soil gas, and groundwater. The breadth of nature and extent information accumulated since 1989 must be noted in the FFS and must be made available in the Administrative Record.	The comment is noted and Section 1.2.2 of the Revised Final SARFFS will be updated to include the information accumulated since 1989.	
Maj-4	EPA	1.3	11			The FFS does not provide sufficient context regarding the remedy in place and the FFS role with respect to that remedy. The current remedy is progressing toward meeting remedial goals and applicable or relevant and appropriate regulations (ARARs), albeit slowly. This FFS is being undertaken to explore ways to expedite the path toward cleanup. In order to do this, the document should set forth the remedial action objectives (RAOs), ARARs, and remedy from the 1989 ROD and relevant Explanations of Significant Difference (ESDs).	As noted in the response to Major Comment No. 1, discussion of the 1989 ROD and the PGA-North remedy-in-place relative to the RAOs and ARARs will be added to the Revised Final SARFFS Report as requested. However, Section 1.3, page 11 currently discusses the History of Remediation Activities – Treatability and Pilot Studies for source area groundwater at PGA-North.	
Maj-5	ITSI Gilbane	2.2	15			The second RAO agreed to during the September 15, 2011, technical meeting was to achieve an 80% reduction in mass flux from the source area. These RAOs were further documented in an e-mail from Catherine Brown on October 21, 2011 (Attachment 3). While the specifics of the mass flux may be defined in future documents, the SARFFS should reflect the agreed-upon RAOs correctly. It is also recommended that two extraction wells be installed in the target treatment zone for mass flux monitoring for indication of interim remedy effectiveness.	The comment is noted and even though the wording of the RAOs is different, the meaning is ultimately the same. The exact wording from the above referenced e-mail will be substituted in accordance with this comment. To address the second part of the comment regarding the need for installation of two extraction wells, we believe the use of new extraction wells for mass flux monitoring is not appropriate. For example, 1) extracted groundwater will contain amendment and products that will foul components of the Main Treatment System; 2) the capture zone associated with two new extraction wells will extend beyond the treatment area resulting in dilution and the collection of performance data not representative of actual geochemical conditions within the treated source area; and 3) similar to General Comment #2, it is likely that these wells could be destroyed during subsequent jet assisted injections of amendment. Target treatment zone wells can be addressed in the design and implementation phases of the project.	We agree that the interim remedy effectiveness issue could be addressed in the design phase of the remedy. No matter what methods are used for mass flux evaluation - transect method, well capture/pumping test method, passive flux meters, or contaminant transport model - a robust groundwater monitoring program will need to evaluate the interim effectiveness of the remedy. We could discuss this issue during our February 2013 quarterly technical meeting.
Maj-6	EPA	2.2	15			Specific to the RAOs, the 1989 ROD contains RAOs for containment and restoration of groundwater throughout the aquifer. With those in place, the RAOs for any action arising from this FFS should proceed based on the original RAOs. There should also be an explanation for how these RAOs are helping to meet the original ones. For instance, if this is the case, we can explain that, in order to achieve restoration in any reasonable timeframe, EPA has determined that an 80% reduction in source mass is necessary.	The comment is noted and language to this effect will be added to Section 2.2.	Acceptable Response.

Agency Evaluation Table to Response to Comments on Final SARFFS (Revision 2 - DRAFT)

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Phoenix-Goodyear Airport North Superfund Site

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Maj-7	EPA	2.2.1	15-16			Remove the term "secondary COC" wherever it is used. Perchlorate is a contaminant of concern (COC). More context regarding perchlorate at the Site would be helpful in explaining its role in the amended remedy. Specifically, this section merely states that the perchlorate is "above 14," but past levels found and current levels are relevant to determining the method to address it. It should be explained clearly in the FFS that perchlorate cannot always be treated with the same technologies as volatile organic compounds (VOCs). Finally, the document must set forth the Site's perchlorate decision history; specifically it should explain that EPA issued a Removal Action Memorandum requiring treatment of perchlorate when it is removed from the aquifer in order to protect human health, but that to date there has not been full analysis of aquifer restoration for perchlorate.	The term "secondary COC" referencing perchlorate will be removed from the Revised Final SARFFS Report as the Crane Co. team agrees that perchlorate is a primary COC at the site. Additional information regarding the nature and extent of perchlorate impacts in groundwater at PGA-North will be added to Section 1.2.3.1, Nature and Extent of Contamination. Expansion of this section may also include a discussion of the spatial distribution of TCE in groundwater at PGA-North to address Major Comment No. 3. Furthermore, an explanation of how in-situ treatment of perchlorate can only be achieved by the remediation alternatives which include bioremediation will be added to Section 3.1, Development of Alternatives. A subsection will be added to Section 1.2.2, Site History, to discuss perchlorate. This section and Section 2.2.3 ARARs will include discussion of the EPA issued Removal Action Memorandum requiring treatment of perchlorate.	By limiting the discussion to in-situ technologies, Crane Co.'s response does not appear to fully address EPA's comment.
Maj-8	EPA	2.2.2	16			The statement that exposure north of the facility will be controlled by health and safety measures needs further elaboration. It is unclear whether this is where it is intended to insert information about institutional controls. Note also that, at the facility at this point, there are few buildings, but ICs will be necessary to ensure that the land use does not change, and, if it does, that the remedy is protective for occupants of any overlying buildings.	The statement is not intended to insert information regarding institutional controls, but rather provide assurance that remediation activities that may potentially take place north of the property boundary+H14would represent no significant risk to workers during implementation of the remedy due to the use of appropriate health and safety measures. None of the active components for any of the remedial alternatives are anticipated to be completed under buildings; therefore ICs are not deemed necessary for areas outside the property. The Consent Decree contains language for future uses of the property and these requirements will be considered in the design phase.	

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Maj-9	ITSI Gilbane	2.2.3				The entire ARARs section is lacking definition and completeness. Although many of the ARARs defined during the previous feasibility study process may remain applicable, additional ARARs would be applicable to the alternatives discussed in this report. Further, during the public comment process for this phase of the project, it is not appropriate to simply reference an outdated list of ARARs. An updated list of ARARs specific to the alternatives discussed in this report is required. As a reference, a sample table of ARARs (not specific to this project) has been prepared to provide an example of how ARARs can be presented to ensure that all ARARs are considered and understood (Attachment 4). Attachment 5 includes a copy of Appendix E - Documentation of ARARs, from the RI/FS Guidance document that was to be followed for preparation of this report, as noted in previous agency comments. As noted in this attachment, the Crane Team is expected to consult with USEPA and ADEQ regarding development of the ARARs. As such, a specific call to discuss ARARs for the SARFFS is recommended.	The Crane Co. team has sufficient information from past experience in EPA Region 9 and in Arizona to compile an updated list of ARARs for the Revised Final SARFFS Report without convening a meeting. Section 2.2.3 will be expanded to include the requested ARARs information.	Acceptable response with comment. Although a draft of the proposed ARARs was not provided for review by the Agency Team, these will be discussed during the PGAN Quarterly Technical Meeting on Feruary 6, 2013. Also, in the event that the Agency Team has comments on the proposed ARARs provided in the Revised Final SARFFS, the Agency Team has the opportunity to revise the ARARs in the Summary of "Remedial Alternatives Section" of the *Proposed Plan* as noted in EPA Guidance EPA 540-R-98-031, *A Guide to Preparaing Superfund Proposed Plans, Records of Decision, and Other Remdy Selection Decision Documents*. It would be helpful if a draft of the Proposed ARARS could be made available for the Quarterly Technical Meeting for discussion at the meeting or for the Agency Team to review and provide comments for use in preparing the Revised Final SARFFS. A complete and accurate delineation of ARARs is a critical component to the future evaluation of the success of the source area remedial action. Clear Creek agrees with ITSI Gilbane that Crane Co should complete this step through consultation with EPA and ADEQ.

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Maj-10	ITSI Gilbane	2.4.3	19			The statement that the existing network of extraction wells is serving as a hydraulic barrier is questionable. Please see the November 28, 2011, technical memo "Revised Technical Comments on Draft Subunit A Capture Zone Report, Phoenix-Goodyear Airport North Superfund Site, Goodyear, Arizona" (Reference: See #11 on 2011 Deliverables Table/#15 on 2012 Deliverables Table). Further, the agency comments regarding the Revised Draft Subunit A Capture Zone Report submitted on October 31, 2012, will be discussed during a conference call scheduled for December 13, 2012. This discussion (as well as subsequent written agency comments that will follow the call) should be used to inform the understanding of this section and overall hydraulic capture as discussed in the FFS.	The Crane Co. team respectfully disagrees that the hydraulic barrier created by the existing extraction well network is questionable. Rather, the evaluation of current field data demonstrates that the capture zone from these wells extends east just beyond Litchfield Road. In an effort to increase hydraulic capture of the Subunit A TCE plume along the Van Buren transect, Crane Co. proposed to install extraction well EA-09 north of Van Buren Street. A primary objective of extraction well EA-09 is to provide enhanced hydraulic control of Subunit A groundwater flow as it relates to the planned source area remediation. It is anticipated that the existing Subunit A MTS extraction well network (EA-01, EA-03, and PZ-01), along with the addition of new extraction well EA-09, will serve as an effective hydraulic barrier for any source area treatment amendment that is selected. It should be noted that the hydraulic barrier required to prevent down-gradient migration and enhance remediation amendment distribution only needs to be slightly larger than the footprint of the conceptual aerial extent of the source area treatment; therefore, the hydraulic barrier (for the purposes of the source area treatment) does not have to encompass the entire width of the Subunit A TCE plume along Van Buren Street (please see Figure 6 of the Final SARFFS for the aerial extent of the source area treatment).	Acceptable response with comment. Resolution of the adequacy of the capture of the Van Buren extraction well line is deferred to the Subunit A Capture Zone report and the evaluation of the performance of EA-09. Clear Creek agrees with the concerns raised by ITSI Gilbane regarding the extent of capture at Van Buren Street. Installation of new extraction well EA-09 is important to address the high concentrations of TCE observed north of Van Buren but it is not a substitute for enhancement of the on-site hydraulic barrier to ensure complete capture at Van Buren Street, closest to the source area, through the rehabilitation or replacement of extraction well EA-04 as previously requested by EPA.
Maj-11	CH2M Hill	Section 3.2		8 through 11		There is inconsistency in the document with the injection well spacing's assumed for Alternatives 3 through 6. While the results of the Phase III Pilot Test were referenced as the basis for injection spacing (a 30-foot radius of influence (ROI) was achieved in Phase III), the injection spacings for Alternatives 3 through 6 are 25 feet, 60 feet, 15 feet, and 60 feet, respectively. Please describe the reasoning for these differing injection spacings. There also is inconsistency within the descriptions of each alternative with regard to injection ROI and spacing. For example, Section 3.2.5 states that for Alternative 4, the "nZVI dose was derived . . . within a 25-foot radius of the injection point," which is different from the 30-foot injection ROI achieved in the Phase III Pilot Study, and conflicts with the 60-foot injection spacing assumed for Alternative 4. Also, Section 3.2.6 states that "injection spacing would need to be 10 feet or less due to the injection characteristics of the ZVI particulate slurry," but the Alternative 5 design injection spacing is 15 feet. Finally, the text of Section 3.2.7 states that "each injection point will be spaced on 50-foot centers" vs. the 60-foot spacing indicated elsewhere for Alternative 6. Please explain or resolve these and other similar discrepancies.	The injection spacing for each of the alternatives was chosen based on the type of amendment, injection method, and Subunit A hydrogeology as outlined below: [SEE TABLE IN ORIGINAL 14 January 2013 RTC] A similar dosing method as was used for the Phase IV Pilot Test was assumed for Alternative 4, and because the pilot test yielded a radius of influence of 30 feet, that distance was also used for the conceptual design of the remedy as described in Section 3.2.5. This approach will be clarified in the text of Section 3.2.5. The language in 3.2.6 will be clarified to indicate that hydraulic fracturing would be used to improve the radius of influence to 15 feet. In Section 3.2.7, this typographic error will be correct to read 60-foot centers.	Acceptable Response.

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Maj-12	CH2M Hill, ITSI Gilbane	2.3 & 3.2				Section 2.3 states that the source area treatment covers and area of 350,000 square feet (sf). In Section 3.2, all the alternatives describe the source area as 250 feet wide by 700 feet long (175,000 sf). Please explain or resolve this discrepancy and make sure other calculations in the document use the correct assumption.	The area defined in Section 2.3 was from a previous iteration of the report and will be updated to 175,000 square feet.	Acceptable Response.
Maj-13	CH2M Hill	3.2.7, App D				While the text states that 290,000 lbs. of permanganate will be injected for Alternative 6, Appendix D (Table D6b) states that 488,060 lbs. will be injected. Please explain or resolve this discrepancy.	The mass listed in the Appendix D is correct and the text will be corrected.	Acceptable Response.
Maj-14	ITSI Gilbane	3.3.2				See ITSI Gilbane comment above (Maj-9) regarding the ARARs discussion/evaluation. That comment also applies to this section, where compliance with the ARARs should be presented for evaluation.	An evaluation of the proposed remediation alternatives relative to achieving the ARARs will be added to this section.	Acceptable response with comment. See evaluation of Maj-9.
Maj-15	EPA	3.3.2	40			The ARARs must be identified before any analysis of whether the alternatives meet them is conducted. Additionally, more information than is currently provided in the FFS may be necessary to determine whether a particular alternative meets the ARARs. For instance, the chemical-specific ARARs require trichloroethene (TCE) to be brought down to below the drinking water maximum contaminant level (MCL). The alternatives here are aimed at reducing mass, but not necessarily getting the TCE to below 5ppb. Elaboration on these alternatives as supplements to the current remedy would be helpful.	This comment is acknowledged, please see above.	

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Maj-16	EPA	3.3.3	41-42		10	EPA has now developed and distributed a Methodology for carbon footprint analysis and a spreadsheet template for applying the methodology to a specific Site. Please see the links below and develop the analysis per EPA guidance. Questions on the use of the Methodology and Spreadsheets for Environmental Footprint Analysis (SEFA) - including scheduling of a Site-specific training workshop - can be directed to Karen Scheuerman of EPA Region 9. She can be reached via email at Scheuermann.Karen@epa.gov or via phone at (415) 972-3356. **Resources:** **EPA's April 2012 Webinar: http://www.clu-in.org/live/archive/** (search for April 2012, then look for "Greener Cleanups - EPA's Methodology for Understanding and Reducing a Project's Environmental Footprint", 18 April 2012) **Fact Sheet for EPA's Footprinting Methodology:** http://clu-in.org/greenremediation/methodology/docs/GR_Overview_of_Footprint_Methodology_FS_3-29-12.pdf **EPA's Footprinting Methodology (full title: "Methodology for Understanding and Reducing a Project's Environmental Footprint"**, issued February 2012): http://www.clu-in.org/greenremediation/methodology/ The SEFA workbooks in template form (full name: "Spreadsheets for Environmental Footprint Analysis"): www.clu-in.org/greenremediation/methodology (scroll to bottom of web page)	A replacement carbon footprint analysis will be developed per EPA guidance as referenced in the above comment. The SARFFS report will be updated accordingly.	

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Maj-17	CH2M Hill	App C4		---	---	The case studies provided in Appendix C describe issues with the implementation of nZVI that are not clearly addressed in the SARFFS: (a) Passivation of nZVI prior to injection due to mixing with oxygenated water occurred in 2 of the case studies. Has the potential issue of nZVI passivation <u>during</u> injection into an aerobic aquifer been accounted for in the design of Alternative 4? (b) For the case study employing pneumatic fracturing, "ZVI mass in excess of the contaminant stoichiometry was necessary to bring about significant abiotic reduction of CVOCs," and the study indicated that "dissolved-phase TCE was treated in the short-term, but sorbed TCE may gradually show up as dissolved-phase in the monitoring wells." As suggested in Major Comment No. 11 to the Draft SARFFS, excess contaminant mass will likely be released during jet-assisted injection and the nZVI stoichiometry calculations need to account for this additional mass in excess of the maximum dissolved-phase concentrations found in monitoring wells. Please provide information in the SARFFS on how this excess contaminant mass released during jet-assisted injection has been accounted for in the reagent mass calculations, or how the reagent demand from sulfate still dominates even when accounting for this excess contaminant mass.	In case (a) above, passivation occurred due to use of oxygenated water. The Phase IV Pilot Test used anaerobic water and thus avoided this problem, therefore, this method was assumed for use with alternatives in the SARFFS that include ZVI as a remediation amendment. In case (b) above, dissolved phase contaminant mass that may gradually show up in groundwater will be subject to ARD and macroscale ZVI in addition to nZVI. The electron donor concentration assumed for application of ARD is dosed to provide an equivalent or greater number of electrons to reduce electron acceptors similar to the nZVI dosage. Additionally, the ZVI dosage is based on the anticipated electron demand of the soil. This dosing strategy provides at least three times the number of electrons as was used during the Phase IV pilot test. This approach will be clarified in the text as necessary. Attached, please find an updated spreadsheet providing the Crane Co. team's response to minor comments (Attachment 1) on the Final SARFFS Report. In addition, Attachment 2 is a narrative and supporting data for site-specific analyses performed to evaluate the potential for permanganate to mobilize metals from site soils. This recently obtained information will be included in the next draft of the SARFFS report.	Acceptable Response.
Minor (Min-) Comments								
Min-1	EPA	1.2.2	2-5			The perchlorate history and context needs revision. This paragraph should explain the highest levels found at the Site historically and the current levels found. Context regarding perchlorate in Subunit C and its connection to Subunit A would be helpful.	Please see the response to Maj-7.	
Min-2	EPA	1.2.2	2-5			We need all the data this FFS considered, as well as the data the PRP decided <u>not</u> to use, so that we at EPA can draw our own conclusions - as can people who want to look at the Administrative Record.	This comment has been noted.	
Min-3	EPA	2.2	15-14			The selection of the RAOs for this FFS needs to be better explained. The document should explain why we need mass and contaminant concentration reductions.	Please see the response to Maj-6.	
Min-4	EPA	2.2.2	16			Throughout the document, but particularly in this section, "site" versus "facility" needs to be clarified.	This comment has been noted.	

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Min-5	EPA	2.2.3	16			Remedies are not selected through enforcement instruments but through agency decision documents. The PGA-North groundwater remedy was selected in the 1989 ROD, subsequent ESDs, and the Removal Action Memo for Perchlorate. The FFS must evaluate whether the ARARs that were established in those documents still apply and whether there are other ARARs relevant to the evaluated alternatives. These ARARs must include any new aspects that might arise from the considered alternatives so that the determination can be made as to whether those alternatives can meet ARARs, including chemical specific (e.g. perchlorate cleanup levels), action specific (e.g. for injection into the subsurface), and location-specific ARARs.	Please see the response to Maj-9 and -14.	
Min-6	EPA	2.2.4	16			The "primary remediation goals" for the Site are containment and aquifer restoration. After that, the methods used, or subgoals, could include reducing mass as ways to help us toward the primary ones.	This comment has been noted.	
Min-7	EPA	2.2.4	16			The FFS appears to be making an additional goal of containment within the source area. This should be discussed in the RAO section as well (potentially as an expansion of the containment RAO).	The RAOs will be updated as discussed in the response to Maj-5.	
Min-8	USACE	2.2.4	16			The quantification of the mass flux will be an important metric for the success of the source area treatment, but this measurement is difficult to make. Once the Subunit A extraction wells along/near Van Buren (EA-03, PZ-01, EA-04, and EA-09) are all in place, data from these wells will provide an excellent mechanism to monitor mass flux (with relative certainty of full capture). The quantification of mass flux must be determined before source area treatment is initiated, and future plans should address this requirement.	This comment has been noted. The design phase for the chosen remedy is anticipated to include an assessment of mass flux and fate and transport modeling to evaluate longevity of amendments.	Acceptable Response.
Min-9	EPA	2.3	16-17			This section needs rewording. As it is, it appears to redefine the remedial goals away from containment and restoration. EPA has not made that determination, and the FFS does not support removal of the original RAOs. This section should clarify that the initial remedial goals remain in place while the goals set forth for this effort supplement the original ones.	Please see response to Maj-1, -5, and -6.	
Min-10	EPA	2.4.1	18			The status of the current remedy (pump and treat and SVE) in the source area must be explained explicitly. It is unclear from this section what parts of the original remedy are expected to remain in place while an alternative from the FFS is implemented.	The current status of the site groundwater remedy, including the pump and treat and SVE components, will be clarified in the section.	
Min-11	EPA	2.4.1	18			Dual phase extraction: Nothing is discussed with regard to perchlorate treatment in this section.	As discussion of dual phase extraction effectiveness on removing perchlorate will be added to this section.	
Min-12	EPA	2.4.1	18			Dual phase extraction: Air emissions treatment must be conducted pursuant to the selected ARARs, not a permit.	This comment has been noted.	

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Min-13	EPA	2.4.1	18			Clarification: IWAS: IWAS should be defined.	This comment has been noted.	
Min-14	EPA	2.4.3	19			In the following sections (here in the second paragraph about active barrier systems) and in the following sections (here in the second paragraph about active barrier systems), it is stated that it has been determined that the source area is cut-off from the downgradient contamination. It should be clarified whether there is sufficient data to show that or whether more needs to be done to assess or accomplish that.	Please see the response to Maj-10.	
Min-15	USACE	2.4.5	20			The in-situ use of hydrogen peroxide is essentially always in the Fenton's reagent mode, not with ultraviolet (UV) light.	This comment has been noted. However, hydrogen peroxide is also used with ozone for application of advanced in -situ oxidation.	Acceptable Response.
Min-16	EPA	2.4.6	21			Clarification: Clarify whether bioaugmentation testing "in the field" is not at this Site itself.	This statement referenced bioaugmentation test performed at other site. This will be clarified in the text.	
Min-17	CH2M Hill				2	For Table 2 referenced in Section 2.4.8, please add explanation of how the use of micro-scale zero valent iron (ZVI) can lead to increases in arsenic. Why would the same issue with increased arsenic not apply for nano-scale ZVI (nZVI)?	An explanation of how dissolved arsenic concentrations can increase in the presence of nZVI and ZVI will be added to Section 2.4.4, and will be referenced in Table 2 as necessary.	Acceptable Response.
Min-18	EPA	3	23			Please clarify what it means that "the alternatives were approved, so they will not be screened."	A description of the screening process for choosing the remediation alternatives is provided in Section 2.4. This text will be revised to refer to this section.	
Min-19	EPA	3	23			Clarification: at this stage in the process, EPA only evaluates the first 7 criteria. State and community acceptance are evaluated following the issuance of the Proposed Plan (unless we already have approval of the state).	This clarification will be added to the appropriate section.	
Min-20	CH2M Hill				3	For Table 3 referenced in Section 3.2.1, under the Alternative 4 and 5 descriptions for Protection of Human Health and Environment, it states that the dissolution of iron hydroxides may result in the production of arsenic (As), hydrogen sulfide (H_2S), and methane (CH_4). Please provide a brief description of geochemical conditions under which iron hydroxides would dissolve (e.g., shift from anaerobic to aerobic conditions). Please also explain how the dissolution of iron hydroxides may result in the production of H_2S, and CH_4, as these are potential byproducts of ARD.	This description will be added to Section 2.4 as appropriate to the technology type, and references will be added to Table 3.	Acceptable Response.
Min-21	EPA	3.2.2	24			It must be made explicit whether the No Action Alternative here refers to true no action or continuation of the current remedy.	This comment has been noted. The baseline is assumed to be a continuation of the current groundwater remedy. This section will be updated to state this assumption.	

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Min-22	EPA	3.2.3	24-26			Assuming that the assumptions made for long-term monitoring are only for costing purposes, that needs to be made explicit. At this stage, no assurances should be made as to the frequency of monitoring (e.g., statements re 3 years of semi-annual monitoring).	This comment has been noted.	
Min-23	EPA	3.2.4	26			The last sentence at the bottom of this page refers to the initial Draft Subunit A Capture Zone Report dated September 23, 2011. This report has since been revised and resubmitted as a revised draft dated October 31, 2012 and is the subject of a conference call on December 13, 2012 to discuss general agency concerns about the report. This portion of the text should be revised to reflect the current status of this report.	Please see the response to Maj-10.	
Min-24	ITSI Gilbane				5,6,7	For Tables 5, 6, & 7 (as referenced in Sections 3.2.4 - 3.2.6), Alternatives 3, 4, and 5 have different radii of influence for injection; however, the proposed quantities for microbial culture and emulsion per injection are the same. These quantities are supposed to be calculated according to (1) the hydrogen demand of major electron acceptors and (2) the ratio between microbial culture and targeted groundwater volume for treatment per injection, and are expected to be different for these three alternatives.	The emulsion dosage and volume of bioaugmentation will be adjusted as necessary for each of the three alternatives; however, the total volume of the emulsion and bioaugmentation culture will not change because it is dependant on the volume and mass of contaminants of and within the treatment area, which do not change.	Acceptable Response.
Min-25	ITSI Gilbane				5, 6,7, 8	For Tables 5, 6, 7, & 8 (as referenced in Sections 3.2.4 - 3.2.7), for these alternatives, the locations for re-injections will be more than 10 percent of the original points. For instance, the typical lifetime in the subsurface for EVO is 3 to 5 years, and the persistence of permanganate in groundwater in this kind of environment is probably less than 5 years. It is very likely that as high as 50% of the locations might need re-injection.	The estimate in these tables is believed to be reasonable for the purpose of the SARFFS.	Acceptable response with comment. This issue could be addressed in the design phase and implementation of the remedy.

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Min-26	ITSI Gilbane	3.2.5	32		6	It is still not known how bioaugmentation will be conducted following ZVI/nZVI injection in this alternative. It is very likely that <u>at least two mobilizations</u> will be needed for a successful bioaugmentation at the Site. This will impact both schedule and cost. The nZVI/ZVI injection (especially nZVI) will result in high pH value in groundwater (higher than 10.8 in pH was observed in nearby monitoring well IW-01 during the Phase II nZVI Pilot Test), and volatile fatty acids resulting from the degradation of simultaneous injection of emulsified vegetable oil (EVO) will help buffer the pH in the groundwater. However, it will take time for these volatile fatty acids to form after injection of EVO. The optimal pH condition for microbial culture such as KB-1 (which Haley & Aldrich proposes to use) is between 6 and 8.5; therefore, it is expected that a couple of months or even several months will be needed before bioaugmentation is feasible, e.g. has measurable positive results. Please comment on this as well as on how this revised approach affects the SARFF ratings for this alternative.	A recent study (Battelle 2012) showed that bioaugmentation that is performed at the same time as electron donor injection can result in the same remediation timeframe as when bioaugmentation is performed separately. Some of the degrader microorganisms die off during the injection, but the lag time in regrowth of the microbial population is matched by the lag in waiting for the aquifer to become anoxic and reducing. At this Site, because the ARD is paired with nZVI and/or ZVI, reducing conditions are immediate and anaerobic water will be used the carrier fluid. Even if an additional mobilization is added for bioaugmentation, the relative evaluation of the alternative will likely not change due to the cost gap between Alternative 7 and the other alternatives.	Acceptable response with comment. Even though bioaugmentation could be done in the same time as electron donor injection, it is not known if bioaugmentation could be conducted in the same time of ZVI/nZVI and electron donor injection because of the potential high pH value caused by the ZVI/nZVI injection.
Min-27	EPA	3.2.5	29-32			The discussion claims that ZVI acts quickly, but there is no discussion of rebound. If there has been rebound, that should be discussed in this section.	This comment has been noted.	
Min-28	ITSI Gilbane	3.2.7	36			The discussion on the use of ISCO as an alternative should mention the potential impacts to the ion exchange resin if water treated with ISCO is extracted along the hydraulic barrier and run through the treatment system. Permanganate ($KMnO_4$) will compete with the perchlorate with the resin and negatively impact the treatment efficiency of the ion exchange vessels. (It is noted that as selective resin is used at the site, and the concentrations of permanganate will be low when it reaches the Van Buren hydraulic barrier, the potential impact on the resin likely is small.)	This comment has been noted.	Response is indefinite. Revision of the narrative with respect to this comment is expected. See also the response to Min-29.
Min-29	USACE	3.2.7	36		8	The second injection of oxidant would likely be needed at more than 10% of the locations - as much as 30-40% is believed to be needed. The same may be true for the bioremediation options, as well.	The estimate in these tables is believed to be reasonable for the purpose of the SARFFS.	While we do not agree with the response, resolution of this does not affect the conclusions. The Agency Team will need to assure that reapplication of the selected amendment is conducted where needed based on monitoring results. We assume that this is an acceptable plan given the use of the Triad approach as discussed by the Crane Team.
Min-30	EPA	3.2.8	29-32			Clarify whether the thermal treatment alternative is implementable in light of the fact that all subsurface features, including wells, must be removed to conduct the alternative. Explain how levels would be monitored and residual contamination would be addressed.	This comment has been noted.	

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Min-31	EPA	3.3.1	39-40			Same as above (Min-21): Alternative 1 is described as absolutely no action. Please clarify.	Please see response to Min-21.	
Min-32	EPA	3.3.1	39-40			The alternatives that do not treat perchlorate could be argued to not meet ARARs. Explain how this is not the case.	We disagree and believe that the alternatives that cannot treat perchlorate do not meet RAO's and possibly ARARs, especially since according to Comment Maj-7, perchlorate is to be considered a contaminant of concern.	
Min-33	ITSI Gilbane	3.3.1	39			The discussion of In-Well Air Stripping (IWAS) mentions the risk of spreading contaminants off site. However, the option calls for the use of IWAS in conjunction with a hydraulic barrier; if an effective hydraulic barrier is maintained, there should be negligible risk of off-site contamination.	This comment has been noted.	Response is indefinite. Revision of the narrative with respect to this comment is expected.
Min-34	EPA	3.3.1	39			For the Alternative 3 analysis, it's unclear how the short-term protectiveness is evaluated if there is potential to stall at vinyl chloride or mobilize arsenic.	This section will be clarified to indicate that mobilization of arsenic is possible using ARD, and that the potential to stall at vinyl chloride is not likely assuming bioaugmentation is successful.	
Min-35	EPA	3.3.1	40			The protectiveness evaluation for Alternative 6 is unclear. The FFS states that the Alternative is "moderately protective," however it also refers to levels of exposure to workers.	Section 3.3.1 stated that there is a low level risk to treatment system workers. This is not inconsistent with being moderately protective.	
Min-36	ITSI Gilbane	3.3.3	39			At the end of the first paragraph, there is a reference to cost information provided in Table 10. Table 10 provides the sustainability evaluation. The cost information is provided in Table 11. Please revise accordingly.	This comment has been noted.	Response is indefinite. Revision of the narrative with respect to this comment is expected.
Min-37	EPA	3.3.3	40			Meeting RAOs as defined here is not the same as long-term effectiveness and permanence. Clarification is necessary.	This comment has been noted.	

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Min-38	ITSI Gilbane	3.3.1	40			The paragraph discussing Alternative 6 states that ISCO/hydraulic barrier would be moderately protective of human health and the environment. This seems a biased statement against ISCO.	Please clarify how this statement is biased against ISCO.	The bias is towards the handling of the Van Buren hydraulic barrier if it completely captures the permanganate solution and untreated source area perchlorate plume. The text stated "...permanganate could be persistent in the environment and lead to the need for strict migration control measures beyond the current hydraulic barrier system", which is likely overstated. This should not cause the ranking of Alternative 6 to be lower than Alternatives 3, 4 and 5 in terms of protectiveness of human health and the environment. In addition, the persistence of permanganate in the environment will be an advantage for ISCO treatment of TCE in the source area, since it will have longer contact time and permanganate will likely diffuse into the fine area. Many studies have shown that the increased metal concentrations after ISCO injection are transient in nature and will attenuate rapidly within a short distance and in time. The anaerobic water created by Alternatives 3, 4, or 5 will be persistent in the area between the treatment area and Van Buren hydraulic barrier.
Min-39	USACE	3.3.3	40			See general comment (Gen-3) above.	Please see response to Gen-3.	See evaluation of Gen-3 above.
Min-40	ITSI Gilbane	3.3.3	40			The list of alternatives that likely would be moderately to highly effective at permanent reduction of source area COCs should include Alternative 6.	This comment has been noted.	Response is indefinite. Revision of the narrative with respect to this comment is expected.
Min-41	EPA	3.3.3	42		10	The focus for the FFS analysis of alternatives is a nine criteria analysis. Sustainability is not one of the nine criteria, and the document should be clear regarding this issue.	This comment has been noted.	
Min-42	ITSI Gilbane	3.3.5	43			The text states "perchlorate degradation has been strongly related to methane generation . . . " In reality, perchlorate degradation generally is related to the denitrification process, not methanogenesis.	This comment has been noted.	Response is indefinite. Revision of the narrative with respect to this comment is expected.
Min-43	USACE	3.3.5	43			Perchlorate degradation is correlated with denitrification, not methane generation. It is readily degraded under anoxic conditions, but you don't need it so reducing so as to be methanogenic.	Please see response to Min-42.	Response is indefinite. Revision of the narrative with respect to this comment is expected.

United States Environmental Protection Agency

Agency Evaluation Table to Response to Comments on Final SARFFS (Revision 2 - DRAFT)

Report Titled, "Source Area Remediation Focused Feasibility Study Report (Final SARFFS Report) Response to 14 December 2012 Comments, Phoenix-Goodyear Airport North Superfund Site, Goodyear, Arizona," Submitted by Haley & Aldrich on 14 January 2013

Phoenix-Goodyear Airport North Superfund Site

Comment Number	Reviewer(s)	Section(s)	Page(s)	Figure(s)	Table(s)	Comment from Agency Team	Crane Team's Response to Comment	Agency Team's Evaluation of Response to Comment
Min-44	EPA	3.3.5	43-44			The criterion is short-term protectiveness, not effectiveness. The alternative discussions need to include protection of workers and others potentially exposed in the short term within this section.	Please see EPA Guidance stating that the criteria is called short term effectiveness. A few references to EPA guidance documents are provided below. - United States Environmental Protection Agency Office of Solid Waste and Emergency Response Directive No.: FS4 March 1990, and, - United Stated Environmental Protection Agency (USEPA), 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies under the Comprehensive Environmental Recovery and Liability Act. October.	
Min-45	ITSI Gilbane	3.3.5	44			The first paragraph states that Alternative 6 (ISCO) would only treat readily available contaminant mass because the aquifer would not be fully permeated, and that the injection process is time-intensive and dispersion of the permanganate is required for the solution to reach between injection points. If fracturing and pressure injection are used, similar to Alternatives 4 and 5, this would not be an issue and the permanganate would be more likely to get into zones of low porosity.	This alternative assumes that jet-assisted fracturing would be used as the injection method. We agree with this comment and will modify the text as appropriate.	Acceptable Response.
Min-46	USCE	3.3.5	44			The difficulty in "fully permeating the aquifer" would apply to the ARD amendments as well as the oxidants.	This comment has been noted.	Response is indefinite. Revision of the narrative with respect to this comment is expected. This is an example of a disadvantage being applied to one alterative but not to another alternative where the same disadvantage is present, which imparts bias on the evaluation.
Min-47	EPA	3.3.8	46			State acceptance is assessed following issuance of the proposed plan. It is often possible to gauge state acceptance at any point in remedial development, but if there has not been an opportunity for formal state comment, this section should be reworded to indicate that it will be assessed later. Note, "federal acceptance" isn't a criterion and should be deleted.	This comment has been noted.	
Min-48	EPA	3.3.9	46			Same as state acceptance above (Min-47).	This comment has been noted.	
Min-49	EPA	3.4.1	47			No action is not protective of human health and the environment, nor does it comply with ARARs. ARARs require restoration of the aquifer to drinking water standards. Doing nothing, or even capturing the contamination at the end, is not in and of itself protective. At least institutional controls (ICs), which would be a remedial component, would be necessary to prevent exposure.	This comment has been noted.	

Agency Evaluation Table to Response to Comments on Final SARFFS (Revision 2 - DRAFT)

Report Titled, "Source Area Remediation Focused Feasibility Study Report (Final SARFFS Report) Response to 14 December 2012 Comments, Phoenix-Goodyear Airport North Superfund Site, Goodyear, Arizona," Submitted by Haley & Aldrich on 14 January 2013

Phoenix-Goodyear Airport North Superfund Site

Comment Number	Reviewer(s)	Section(s)	Page(s)	Figure(s)	Table(s)	Comment from Agency Team	Crane Team's Response to Comment	Agency Team's Evaluation of Response to Comment
Min-50	USACE	3.4.3	48			The disadvantages for ARD should include the potential for biofouling wells.	This comment has been noted.	Response is indefinite. Revision of the narrative with respect to this comment is expected. This is an example of a disadvantage being applied to one alterative but not to another alternative where the same disadvantage is present, which imparts bias on the evaluation.
Min-51	ITSI Gilbane	3.4.4	48			This section states that Alternative 4, nZVI-ZVI plus ARD plus hydraulic barrier, has been bench and pilot tested. The use of nZVI and ZVI have been tested independently; however, it is possible that the use of both together, depending on the injection configuration, could cause the fractures to clog up from the ZVI.	The larger grain size of the ZVI would serve to prop the fractures open, not clog them up.	Acceptable Response.
Min-52	ITSI Gilbane	3.4.4	48			The text states "The high activity of the nZVI destroys both perchlorate and TCE upon contact." Various studies have shown that nZVI has limited direct impact on perchlorate degradation, though it will facilitate the bioremediation of perchlorate in groundwater.	This comment has been noted.	Response is indefinite. Revision of the narrative with respect to this comment is expected.
Min-53	USACE	3.4.4	49			Alternative 4 has the third highest cost, not the fifth highest. (Note that Table 11 shows a range of costs for the in-situ thermal alternative that is not -30/+50% - more like -50/+100% - this should be corrected).	This comment has been noted. The range in cost for the thermal alternative will be reviewed and adjusted as necessary.	Acceptable Response.
Min-54	ITSI Gilbane	3.4.4	49			It is true that the ZVI will have better longevity in the source zone, but its radius of influence (ROI) will likely be smaller than that of the nZVI.	This comment has been noted. The distribution of ZVI will be limited to the extent of the fractures formed during injection.	Acceptable Response.
Min-55	ITSI Gilbane	3.4.5	50			The cost of hydraulic fracturing and injection is considered a disadvantage for Alternative 5 but not for the other alternatives that rely on this. This should be considered evenly for all technologies, as applicable.	Hydraulic fracturing is a different method than jet- assisted injection. The process of hydraulic fracturing is much lower pressure and requires a specialized tooling to initiate a notch in the formation to begin propagation of fractures. This process is quite different from jet-assisted injection and this will be explained in the text.	Acceptable Response.
Min-56	ITSI Gilbane	3.4.6	50			The SARFFS lists as a disadvantage of Alternative 6 that chromium may be converted from trivalent chromium (Cr^{3+}) to hexavalent chromium (Cr^{6+}) from permanganate, thereby increasing its mobility and toxicity. However, Cr6+ would be likely to reduce back to Cr3+ as it is mixed with untreated aquifer water.	This comment has been noted.	Response is indefinite. Revision of the narrative with respect to this comment is expected.

Agency Evaluation Table to Response to Comments on Final SARFFS (Revision 2 - DRAFT)

Report Titled, "Source Area Remediation Focused Feasibility Study Report (Final SARFFS Report) Response to 14 December 2012 Comments, Phoenix-Goodyear Airport North Superfund Site, Goodyear, Arizona," Submitted by Haley & Aldrich on 14 January 2013

Phoenix-Goodyear Airport North Superfund Site

Comment Number	Reviewer(s)	Section(s)	Page(s)	Figure(s)	Table(s)	Comment from Agency Team	Crane Team's Response to Comment	Agency Team's Evaluation of Response to Comment
Min-57	ITSI Gilbane	3.4.6	50			The SARFFS lists as a disadvantage of Alternative 6 that it may result in incomplete treatment in the MDWSA. This same argument also can be made about Alternatives 4 and 5. If the injections are done correctly and adequate data are collected regarding fracture patterns and the ROI of injectate, then Alternatives 4, 5, and 6 could all be effective.	The difference between Alternative 6, and Alternatives 4 and 5 is that the permanganate must come in contact with the target chemical and that it is not effective in treating perchlorate. Therefore, incomplete treatment of the MDSWA would result from application of Alternative 6.	Response to this comment is accepted. W e agree that the main difference is the effectiveness in treating perchlorate. F or any injected media, it must come in contact with the target chemical in order to be effective in remediation. There is no difference between alternatives 4, 5, and 6 in this regard.
Min-58	USACE	3.4.7	51			Perchlorate would be driven ahead of a steam front, if steam was a component of the in-situ thermal treatment.	This comment has been noted.	Response is indefinite. Revision of the narrative with respect to this comment is expected.
Min-59	EPA	3.4.7	51			This is the only alternative that mentions potential rebound. Clarify whether the other alternatives have that potential as well.	This comment has been noted.	
Min-60	ITSI Gilbane	Ref	52			The Final Source Areas, Soil, and Facility Structures Investigation Report listed as Reference 8 was supplemented by an additional Responsiveness Summary dated October 26, 2011, which should be listed as a reference, since approval of the Final SASFS Report was not provided until this Responsiveness Summary was approved.	A reference to the additional Responsiveness Summary will be added to the text and references of the SARFFS report.	Acceptable Response.
Editorial (Edit-) Comments								
Edit-1	ITSI Gilbane	3.3.1	40			The text for Alternatives 4 & 5 is included in the text for Alternative 3. To make this information more reader-friendly regarding discussion of all alternatives in this section, it is recommended that the text on Alternatives 4 & 5 be moved to a new paragraph.	This comment has been noted.	Response is indefinite. Revision of the narrative with respect to this comment is expected.

ATTACHMENT 2

Arizona Department of Environmental Quality Comments Letter Dated January 28, 2013
for the
SARFFS Response to 14 December 2012 EPA Comments
January 14, 2013
PGA North

ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY

1110 West Washington Street • Phoenix, Arizona 85007
(602) 771-2300 • www.azdeq.gov

Janice K. Brewer
Governor

Henry R. Darwin
Director

January 28, 2013
FPU 13-125

Catherine Brown
Superfund Remedial Project Manager
US Environmental Protection Agency
75 Hawthorne Street (SFD-6-2)
San Francisco, CA 94105

RE: PGAN – Agency Evaluation on Response to Comments on the Final Draft Report on Source Area Remediation Focused Feasibility Study for the former Unidynamics Facility, Phoenix Goodyear Airport – North Superfund Site located in Goodyear, Arizona

Dear Ms. Brown:

The Arizona Department of Environmental Quality's Federal Projects Unit has reviewed the Response to Comments on the Final Draft Report on Source Area Remediation Focused Feasibility Study for the former Unidynamics Facility and finds the document complete as long as Crane company performs the agreed upon edits, additional text and analyses requested from EPA's review.

If you have any questions regarding this correspondence, please contact me at (602) 771-4196.

Sincerely,

Travis Barnum
Federal Project Unit
Remedial Projects Section
Waste Programs Division

cc:

Michael Long, Hargis (electronic)
Nancy Nesky, ITSI (electronic)

ATTACHMENT 3

Clear Creek Associates Comments Letter Dated January 28, 2013 for the
SARFFS Response to 14 December 2012 EPA Comments
January 14, 2013
PGA North

CLEAR CREEK ASSOCIATES

Practical Solutions
In Groundwater Science

6155 East Indian School Rd.
Suite 200
Scottsdale, Arizona 85251
480-659-7131 office
480-659-7143 fax
www.clearcreekassociates.com

January 28, 2013

Ms. Catherine Brown
Remedial Project Manager
U.S. EPA Region 9
75 Hawthorne Street (SFD-6-2)
San Francisco, CA 94105

Re: Crane Co January 14, 2013 Response to EPA Comments, Source Area Remediation Focused Feasibility Study Report (SARFFS)

Dear Ms. Brown:

Clear Creek appreciates the opportunity to review Crane Co's Response to EPA Comments on the above referenced report. Clear Creek provides the following comments on behalf of the City of Litchfield Park and the City of Avondale.

Response to General Comment No. 1 (ITSI Gilbane) and General Comment No. 3 (USACE)
Crane Co.'s response indicates that they will review the draft SARFFS report and adjust language to address perceived bias in its evaluation; however, Crane Co continues on to highlight the potential for the ZVI and ARD approach to address perchlorate. Clear Creek notes that the magnitude of perchlorate impacts in the source area is far less than the magnitude of TCE impacts in the source area. Accordingly, the primary consideration should be the remedial alternatives potential effectiveness in meeting remedial objectives for TCE.

Additionally, for nZVI alternatives that rely on jet assisted injection, field evidence is currently lacking to demonstrate this techniques' effectiveness to emplace a nZVI barrier of sufficient thickness throughout the targeted depth interval. This uncertainty is understated in the draft SARFFS. Finally, the uncertainty associated with the sustainability of the chloroethene degrading microorganisms (as recognized in Crane Co.'s response to General Comment No. 5 [CH2M Hill]) is also understated in the draft SARFFS.

Response to General Comment No. 5 (CH2M Hill)
The potential advantage for ISCO to diffuse into fine grained and no flow zones, thereby reducing the potential for back diffusion of TCE over time, is understated in the draft SARFFS. See also comments above.

Major Comment No. 7 (EPA)
By limiting the discussion to in-situ technologies, Crane Co.'s response does not appear to fully address EPA's comment.

Major Comment No. 9 (ITSI Gilbane)
A complete and accurate delineation of ARARs is a critical component to the future evaluation of the success of the source area remedial action. Clear Creek agrees with ITSI Gilbane that Crane Co should complete this step through consultation with EPA and ADEQ.

Major Comment No 10 (ITSI Gilbane)
Clear Creek agrees with the concerns raised by ITSI Gilbane regarding the extent of capture at Van Buren Street. Installation of new extraction well EA-09 is important to address the high concentrations of TCE observed north of Van Buren but it is not a substitute for enhancement of the on-site hydraulic barrier to ensure complete capture at Van Buren Street, closest to the source area, through the rehabilitation or replacement of extraction well EA-04 as previously requested by EPA.

* * * * *

Sincerely,

Clear Creek Associates, PLC

Thomas R. Suriano, R.G.
Principal Hydrogeologist

Appendix B: Response to Comments Index
Source Area Remediation Focused Feasibility Study (SARFFS)
Phoenix-Goodyear Airport-North, Goodyear, Arizona

Comment	Section(s)	Page(s)	Table(s)	Appendix	Location of Changed Text in SARFFS	Notes
General Comment No. 1					Executive Summary, Comparative Analysis, Section 3.3 Comparative Analysis Summary, Section 3.4	Scoring table was removed from SARFFS as agreed during 11 July 2012 Technical Working Group meeting.
General Comment No. 2			---	---	Case Studies are references throughout document, and are summarized in Appendix C.	
General Comment No. 3					See General Comment No. 1	see General Comment No. 1
General Comment No. 4					Additional discussion of this approach was conducted during SARFFS Technical Working Group meetings conducted on 9 March 2012 and 11 July, 2012.	Response to Comments (RTC) was accepted with modifications in e-mail from the Environmental Protection Agency (EPA) on 27 July 2012.
General Comment No. 5			---	---	Performance monitoring wells were added to each alternative as shown in the conceptual design figures for each alternative and in the summary tables.	
Major Comment No. 1	1.2.3.3	7			Text was added as stated in the original RTC dated 11 May 2012.	
Major Comment No. 2	1.2.3.3	7			Text was added to the referenced section as stated in the original RTC dated 11 May 2012.	
Major Comment No. 3	1.3.7	12			Text was added to Section 1.3.7 and to the description of Alternative 4 in Section 3.2.4 on page 28.	
Major Comment No. 4			2		A column was add to Table 2 to provide the rationale for acceptance or elimination of the remediation technologies under consideration.	
Major Comment No. 5	2.4.3	16			See Major Comment No. 4	
Major Comment No. 6	2.4.7	18			Steam was included in the title for Alternative No. 7 because it is included in the design and cost.	This is a departure from the response provided in the RTC. This alternative was redesigned to include treatment of mass within the property boundary in order to provide a more pragmatic application for this technology.
Major Comment No. 7	3.2.3	21			No text was added to the SARFFS; this comment was addressed in the RTC.	
Major Comment No. 8	3.2.3	22	4		Text was added to Table 4 to address this comment.	
Major Comment No. 9	3.2.4	25	5		The rationale behind the conceptual design for the ARD alternative was added to the description in Section 3.2.4.	
Major Comment No. 10	3.2.5	26-27	6		The text provided in the RTC was added to Section 3.2.5.	
Major Comment No. 11	3.2.6	28-29	7		This text was updated to reflect the actual dosing method used for the ZVI product. This information was added to Section 3.2.6	a) This reponse was changed to read that the EHC dosage was based on a target volume of 0.61% of soil within the treatment area. The remaining responses were added as stated in the RTC.
Major Comment No. 12	3.2.7	30	8		Appendix D contains the permanganate dosing calculation used for costing Alternative 6 ISCO + hydraulic control.	

Appendix B: Response to Comments Index
Source Area Remediation Focused Feasibility Study (SARFFS)
Phoenix-Goodyear Airport-North, Goodyear, Arizona

Comment	Section(s)	Page(s)	Table(s)	Appendix	Location of Changed Text in SARFFS	Notes
Major Comment 13	3.2.8	32	9		The ERH + steam alternative was adjusted for a treatment area located on-property which includes the source area and the 10,000 ug/L contour of the plume. All of the responses were incorporated into the description for this alternative.	
Major Comment 14	3.3.1.1	33			Section 3.3.3.1 has become Section 3.3.1. Part a) of this comment has been added to Section 3.3.3 in the form of a summary table. Part b) has been added to various portions of Section 3.3 as appropriate. Part c) has been added to text located in both Section 3.3 and 3.4 and Table 3.	
Major Comment 15	3.3.1.3	34			Section 3.3.1.3 has become Section 3.3.3. Part a) of this comment has been addressed in Section 3.3.3 and 3.3.4. Part b), c) and d) have been addressed throughout Sections 3.3 and 3.4.	
Major Comment 16	3.3.1.4	35			Section 3.3.1.4 has become Section 3.3.4, and this comment was addressed therein.	
Major Comment 17	3.3.1.5	35			Text in Sections 3.2.5 and 3.4.4 were updated to reflect this comment.	
Major Comment 18	3.3.1.6	36			Section 3.3.1.6 has become Section 3.3.6, and Part a) was addressed in Section 3.2.4. Part b) was addressed in every section addressing injection of amendments, and Part c) was addressed in Section 3.4.7.	
Major Comment 19	3.3.1.7	36			Cost backup has been referenced in the cost tables and is provided in Appendix D.	
Major Comment No. 20	3.4.1	40			The text in Section 3.4.3 has been updated to respond to this comment.	
Major Comment 20	3.3.1.8 and 3.3.1.9	38			Table 3 has been changed to show that there has not been any public, state or federal endorsement of the proposed alternatives.	
Major Comment No. 21	3.4.1	40			Section 3.4.3 has been updated with the approved response for this comment.	
Major Comment No. 22	3.4.1	42			Section 3.4 has been updated to reflect nature of this comment and response.	
Major Comment No. 23			D		The sustainability evaluation is now presented in Appendix E, and is summarized in Section 3.3.3.	

TABLE 3
DETAILED COMPARATIVE ANALYSIS **(REVISED, 19 July 2012)**
FEASIBILITY SCREENING RESULTS
PHOENIX-GOODYEAR AIRPORT-NORTH SUPERFUND SITE
GOODYEAR, ARIZONA

Evaluation Criteria	Alternative 1 No Action	Alternative 2 In-Well Air Stripping + Hydraulic Barrier	Alternative 3 ARD + Hydraulic Barrier	Alternative 4 nZVI + mZVI Injection + ARD + Hydraulic Barrier	Alternative 5 ZVI Injection + ARD + Hydraulic Barrier	Alternative 6 ISCO (Permanganate) + Hydraulic Barrier	Alternative 7 Electrical Resistive Heating + Hydraulic Control
Protection of Human Health and the Environment	**LOW-MODERATE** Not Protective of the environment. There is no change in human health impacts if no treatment of the MDWSA is implemented. There are currently no complete human exposure pathways for COCs located on the former Unidynamic property.	**LOW-MODERATE** Protective of human health, however may not be protective of the environment since heterogeneity of a lithologic layers may limit recirculation pathway. **Potential for spreading of contaminants.**	**MODERATE** Protective of human health and the environment over the long-term. May result in temporary increases in VC concentrations, although recent changes in understanding place the toxicity of TCE equivalent to that of VC. **Is protective, but has risk of generating vinyl chloride that may create vapor intrusion issue.** **Dissolution of iron hydroxides may result in the production of As, H_2S and CH_4.**	**HIGH** Immediately more protective of human health and the environment. May result in temporary increases in VC concentrations, although recent changes in understanding place the toxicity of TCE equivalent to that of VC. **Similar to the ARD alone, but with a lower likelihood of generating vinyl chloride.** **Dissolution of iron hydroxides may result in the production of As, H_2S and CH_4.**	**HIGH** Immediately more protective of human health and the environment. May result in temporary increases in VC concentrations, although recent changes in understanding place the toxicity of TCE equivalent to that of VC. **Has similar protective qualities to Alternative 4.** **Dissolution of iron hydroxides may result in the production of As, H_2S and CH_4.**	**HIGH** Protective provided pilot test results are positive. **The use of an oxidant may locally mobilize Cr, U, and Se.** **Concentrations of Cr are presently higher that recommended drinking water level of 6 µg/L. This technology may result in production of CrVI in exceedance of MCLs.**	**HIGH** Protective provided pilot test results are positive. Thermal remediation systems incorporate process controls during implementation that monitoring the treatment system(s) and emissions to assure that the risks to construction works, on-site workers, off-site residents, and the environment are maintained at or below allowable levels.
Compliance with ARARs	**LOW** Complies with ARARs ; however, RAOs would not be met.	**HIGH** Complies with ARARs	**HIGH** Complies with ARARs	**HIGH** Complies with ARARs	**HIGH** Complies with ARARs	**HIGH** Complies with ARARs	**HIGH** Complies with ARARs

A0CXEDJB:
Dissolution of iron oxyhydroxides would not produce H2S or CH4. I thought we agreed to removing the H2S issue as there is enough iron to precipitate the S-2 as pyrite.

Dissolution of iron hydroxides may mobilize Fe, Mn, and As. CH4 is from carbon substrate fermentation process. H2S is produced from sulfate reduction process, if there is enough ferrous iron in the solution, then H2S is not a concern.

A0CXEDJB:
I would take away the language in green.

TABLE 3
DETAILED COMPARATIVE ANALYSIS **(REVISED, 19 July 2012)**
FEASIBILITY SCREENING RESULTS
PHOENIX-GOODYEAR AIRPORT-NORTH SUPERFUND SITE
GOODYEAR, ARIZONA

Moderate-High

Evaluation Criteria	Alternative 1 No Action	Alternative 2 In-Well Air Stripping + Hydraulic Barrier	Alternative 3 ARD + Hydraulic Barrier	Alternative 4 nZVI + mZVI Injection + ARD + Hydraulic Barrier	Alternative 5 ZVI Injection + ARD + Hydraulic Barrier	Alternative 6 ISCO (Permanganate) + Hydraulic Barrier	Alternative 7 Electrical Resistive Heating + Hydraulic Control
Long-Term Effectiveness and Permanence	**LOW** Not effective in the long term due to presence of high concentrations and lack of intrinsic degradation.	**LOW-MODERATE** Effective, however degree of effectiveness and permanence would be determined after implementation of a pilot test. Will likely be limited by the solubility of TCE and the varied lithology. Presence of less permeable layers will likely result in incomplete recirculation of groundwater between upper and lower screens. Formation of preferential flow paths are likely given the site lithology potentially preventing access to low permeability portions of the aquifer. **This technology has a low-moderate likelihood of attaining the total mass removal goal due to the heterogeneities.**	**MODERATE** More effective over the long term than the short term. Degree of effectiveness and permanence would be better understood after implementation of a treatability and pilot study. Once reductive dechlorination processes are established, the reduction in mass is permanent. Multiple injections of electron donor will likely be necessary due to the very low organic carbon content of native soils at the site. **The ability to completely distribute the amendments, particularly the innoculum of DHC is not certain, given the heterogeneity. The alternative will results in long-term aesthetic impact to the aquifer (anaerobic water).** **Potential for biodegradation of perchlorate.** **Anaerobic water will migrate and will be mixed with aerobic water downgradient of the injection zone. This mixing process will result in re-oxygenation of the water and will control the migration of anaerobic water, iron, and manganese out of the source area. The mixing will be enhanced by the presence of extraction wells from the hydraulic barrier.** **Anaerobic water could migrate with groundwater and be extracted and processed through the ex-situ treatment system. If it reaches the extraction wells it may cause fouling of the extraction wells and air-stripping unit. The aboveground treatment units may need to be periodically sanitized to remove**	**HIGH** Successful bench and pilot testing has been completed for nZVI injections. nZVI is very reactive for a short period of time (likely less than 3 months) at which time ARD would be the primary treatment technology. An ARD treatability study is needed to determine design factors critical to the degree of long-term effectiveness and permanence of this alternative. **The addition of macro-scale ZVI to this alternative increases the longevity of the chemical reduction degradation processes.** **The alternative has slight advantage over ARD alone in that the nZVI and mZVI will assist in developing conditions for reductive dechlorination and will contribute mass reduction. The alternative will result in long-term aesthetic impact to the aquifer (anaerobic water).** **Potential for biodegradation of perchlorate.** **Anaerobic water will migrate and will be mixed with aerobic water downgradient of the injection zone. This mixing process will result in re-oxygenation of the water and will control the migration of anaerobic water, iron, and manganese out of the source area. The mixing will be enhanced by the presence of extraction wells from the hydraulic barrier.** **Anaerobic water could migrate with groundwater and be extracted and processed through the ex-situ treatment system. If it reaches the extraction wells it may cause fouling of the**	**MODERATE-HIGH** Effective, however degree of effectiveness and permanence would be determined after implementation of a pilot program. Distribution of micro-scale ZVI is limited by particle size, however micro-scale ZVI is persistent in the environment allowing for effective long-term treatment. The conceptual design for this alternative relies on mass flux to complete treatment of dissolved phase TCE and perchlorate in groundwater together with biodegradation over the long term. The injection design does not rely on injection facilitated contact which may result in less contact under the varied stratigraphic condition present at the site. **Potential for biodegradation of perchlorate.** **Similar to Alternative 4, but granular or ZVI from iron filings has a longer active life than nZVI. Has higher likelihood of success than Alts 2-4. The alternative will result in long-term aesthetic impact to the aquifer (anaerobic water).** **Anaerobic water will migrate and will be mixed with aerobic water downgradient of the injection zone. This mixing process will result in re-oxygenation of the water and will control the migration of anaerobic water, iron, and manganese out of the source area. The mixing will be enhanced by the presence of extraction wells from the hydraulic barrier.** **Anaerobic water could migrate**	**MODERATE** Effective, however degree of effectiveness and permanence would be determined after implementation of a pilot program. Direct contact between the permanganate and TCE molecules are necessary for this technology to be successful. Residual TCE contained in lower permeability zones are likely to remain untreated. Due to low oxidant demand typical of aquifers in Arizona persistence of permanganate in Subunit A is very high, leading to concerns regarding longevity and need for strict migration control. Not effective with perchlorate. Rebound is typically high with implementation of this technology due to lack of adequate distribution. Channeling of injectate in preferential flowpath is common in implementation of this technology in desert aquifers, leading to inadequate distribution. **Persistence of permanganate allows diffusion into low-permeability materials, but this will have a considerable time factor. Has possibility to persist if dosing is too large. Multiple injections may be needed to fully treat all target areas. Has moderate to high likelihood of success. The alternative will result in long-term aesthetic impact to the aquifer (colored water).** **No potential for the biodegradation of perchlorate** **Permanganate could migrate with groundwater and be extracted and processed through the ex-situ treatment system. Mixing and dispersion will reduce MNO_4 concentrations with downgradient migration. If it reaches the extraction wells it may cause fouling of the extraction wells and air-stripping unit, and may eventually result in either adding a treatment unit to neutralize the oxidized, permanganate-laden**	**HIGH** Effective, however degree of effectiveness and permanence would be determined after implementation of a pilot program. A portion of the source zone will not be treated using ERH and/or Steam Injection. The overall removal efficiency of thermal applications is typically greater than 90% if the entire source area is treated. The removal of this mass is expected to occur over a relatively short period of time (approximately six to nine months of operation) with a two to three month installation period. Has highest likelihood of success

A0CXEDJB:
I would remove this paragraph (and the others for Alt 4, 5. The downgradient mixing will likely not be immediate.

A0CXEDJB:
Permanganate will also react with natural organic material. This will also limit downgradient distribution. Well fouling is generally not a problem at the concentrations that would exist downgradient at the extraction wells.

The main mechanism for permanganate attenuation is not mixing or dispersion, rather reaction with organic carbon or minerals in reduced state (natural oxidant demand) in the sediment.

TABLE 3
DETAILED COMPARATIVE ANALYSIS **(REVISED, 19 July 2012)**
FEASIBILITY SCREENING RESULTS
PHOENIX-GOODYEAR AIRPORT-NORTH SUPERFUND SITE
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Evaluation Criteria	Alternative 1 No Action	Alternative 2 In-Well Air Stripping + Hydraulic Barrier	Alternative 3 ARD + Hydraulic Barrier	Alternative 4 nZVI + mZVI Injection + ARD + Hydraulic Barrier	Alternative 5 ZVI Injection + ARD + Hydraulic Barrier	Alternative 6 ISCO (Permanganate) + Hydraulic Barrier	Alternative 7 Electrical Resistive Heating + Hydraulic Control
			biological growth and precipitates, and may eventually result in either adding a treatment unit to deliberately oxygenate the water to remove the high oxygen demand and precipitates. This would result in additional replacement costs for extraction wells and system treatment components. Addition of a recirculation line for reinjection of impacted water will remove potential impacts to the MTS. This will add additional costs for implementation due to the installation of injection wells and extraction wells	extraction wells and air-stripping unit. The aboveground treatment units may need to be periodically sanitized to remove biological growth and precipitates, and may eventually result in either adding a treatment unit to deliberately oxygenate the water to remove the high oxygen demand and precipitates. This would result in high replacement costs for extraction wells and system treatment components. Addition of a recirculation line for reinjection of impacted water will remove potential impacts to the MTS.	with groundwater and be extracted and processed through the ex-situ treatment system. If it reaches the extraction wells it may cause fouling of the extraction wells and air-stripping unit,. The aboveground treatment units may need to be periodically sanitized to remove biological growth and precipitates, and may eventually result in either adding a treatment unit to deliberately oxygenate the water to remove the high oxygen demand and precipitates. This would result in high replacement costs for extraction wells and system treatment components. Addition of a recirculation line for reinjection of impacted water will remove potential impacts to the MTS.	purple water and or high replacement costs for extraction wells and system treatment components. Addition of a recirculation line for reinjection of impacted water will remove potential impacts to the MTS. This will add additional costs for implementation due to the installation of injection wells and extraction wells. Furthermore, since ISCO will not treat perchlorate, the mounding associated with the recirculation system will spread perchlorate contamination and the ISCO amendment upgradient from the source area and potentially toward public water supply wells.	

ARD generally will have more fouling problem than permanganate. There is potential biofouling problems at the injection wells at the treatment area, which is not mentioned here.

A0CXEDJB:
I am confused by the recirculation discussion. You still need treatment and you would have the likelihood of fouling at the plant. The injected water would still be captured (usually you inject less in the target area than you pump just downgradient).

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Reduction of Toxicity, Mobility, or Volume	**LOW** No reduction of toxicity, mobility or volume would occur.	**LOW-MODERATE** Pilot program needed to determine the degree of mass reduction that can be achieved. Reduces toxicity by stripping TCE from groundwater, reduces mobility by extracting impacted groundwater from the aquifer. May not address high VOC concentrations present in lower permeability zones. **Has a low-moderate likelihood to remove significant amounts of mass. Has a risk to increase volume of contaminated water through vertical transfer and mixing.**	**MODERATE** The degree to which contaminant mass would be reduced would be determined by a new treatability study. The hydraulic barrier would be effective at preventing off-Site plume migration. **Potential for biodegradation of perchlorate.** **Provides a permanent reduction in contaminant concentrations and partitioning of VOCs into emulsified oil reduces mobility. May increase the toxicity through temporary production of VC and local mobilization of arsenic. Injection may affect plume flow paths resulting in slight expansion of plume.** **Anaerobic water will migrate and will be mixed with aerobic water downgradient of the injection zone. This mixing process will result in re-oxygenation of the water and will control the migration of anaerobic water, iron and manganese out of the source area. The mixing will be enhanced by the presence of extraction wells from the hydraulic barrier.**	**MODERATE-HIGH** Pilot testing has demonstrated 60 – 93% reduction in contaminant mass in a limited area of the MDWSA. With full-scale implementation of this remedial alternative to the MDWSA the rebound observed during the pilot test is anticipated to be less and follow-up injection are included as part of the multi-year design. Additionally, the hydraulic barrier would prevent downgradient mass flux. **Potential for biodegradation of perchlorate.** **The alternative provides more reduction in contaminant toxicity than Alternative 2 due to the reaction with nZVI. Still has the reduction in mobility resulting from partitioning to oil, but has potential to alter flowpaths.** **Anaerobic water will migrate and will be mixed with aerobic water downgradient of the injection zone. This mixing process will result in re-oxygenation of the water and will control the migration of anaerobic water, iron and manganese out of the source area. The mixing will be enhanced by the presence of extraction wells from the hydraulic barrier.**	**MODERATE-HIGH** The degree to which contaminant mass would be reduced would be determined by the pilot program. The hydraulic barrier would be effective at preventing off-Site plume migration. **Potential for biodegradation of perchlorate.** **Similar to Alternative 4.** **Anaerobic water will migrate and will be mixed with aerobic water downgradient of the injection zone. This mixing process will result in re-oxygenation of the water and will control the migration of anaerobic water, iron, and manganese out of the source area. The mixing will be enhanced by the presence of extraction wells from the hydraulic barrier.**	**MODERATE-HIGH** The degree to which contaminant mass would be reduced would be determined by the pilot program. The hydraulic barrier would be effective at preventing off-Site plume migration. This alternative would not be effective at treating perchlorate. **There would be a reduction in contaminant toxicity. The injection may slightly increase volume of contaminant plume due to spreading, has potential to alter flow paths and may locally mobilize Cr, U and Se.** **Mixing and dispersion will reduce MNO_4 concentrations with downgradient migration.**	**HIGH** The degree to which contaminant mass would be reduced would be determined by the pilot program. It is expected that this alternative would remove and/or oxidize most of the VOCs in the treatment zone. The overall removal efficiency is estimated to be at least 90% based on similar sites. The design of the in-situ thermal heating application would include measures to reduce the potential for contaminant mobilization. During operation, the volume of water within the treatment zone will be reduced. **Greatest reduction in volume and mobility. Does have some slight risk of translating contaminant outside treatment zone.** **Thermal does not remove perchlorate because of its high boiling point.**

A0CXEDJB:
Again, there will be reactive loss of permanganate to some extent.

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Short-term Effectiveness	**LOW** Not effective in the short-term.	**LOW – MODERATE** In-well air stripping would be moderately effective at reducing dissolved phase mass in the short term. This technology would not be effective in treatment of perchlorate. Biological degradation of perchlorate occurs under anaerobic and reducing conditions. **It would take a while to actually see a significant change, and has the potential for short circuiting and the creation of preferential pathways.**	**LOW** ARD is not considered effective in the short term. The high sulfate concentrations in groundwater will require a long acclimation time for the site to reach anaerobic and reducing conditions necessary for degrader populations to grow and degrade significant mass. This technology is likely to be effective with enhancing degradation of perchlorate at similar rates to TCE. Perchlorate degradation has been strongly related to methane generation, indicating that perchlorate would likely degrade before TCE. **The application will take several years to fully begin to address that contamination and has the potential for short-circuiting and the creation of preferential pathways; may result in the mobilization of arsenic.**	**HIGH** nZVI would be effective at reducing contaminant mass in the short term. This technology is likely to be effective with enhancing degradation of perchlorate at similar rates to TCE. **Will still require several years to implement, but the nZVI will allow more rapid reductions in the contaminant concentrations. There is minor risk to overlying land use due to fracturing and slight risk to workers due to the high pressures used during injection. There a slight potential for short circuiting and the creation of preferential pathways.** **The risk to workers can be mitigated through worker awareness training. It is a manageable risk. The depth of the high pressure injection prevents surface effects.**	**MODERATE-HIGH** ZVI would be moderately effective at reducing contaminant mass in the short term. This technology is likely to be effective with enhancing degradation of perchlorate at similar rates to TCE. **This has similar time-frame for benefits as Alternative 4; there are slight risks to overlying land use associated with the fracturing and worker risks due to high pressures used, and has the potential for short circuiting and the creation of preferential pathways.** **The risk to workers can be mitigated through worker awareness training. It is a manageable risk. The depth of the high pressure injection prevents surface effects.**	**HIGH** Permanganate would be effective at reducing readily available contaminant mass in the short term. Not effective with perchlorate. **Reactions occur more quickly, but still takes time to implement. Dispersion and diffusion still required to reach contaminant between some injection points. There are slight risks to overlying land use associated with the fracturing and worker risks due to high pressures used, and has the potential for short-circuiting and the creation of preferential pathways.** **The risk to workers can be mitigated through worker awareness training. It is a manageable risk. The depth of the high pressure injection prevents surface effects. The transport process represents a potential risk to MTS workers and downgradient residents**	**HIGH** Site preparation and ERH and/or Steam Injection system operation is expected to require approximately one year (including installation and demobilization). **Will take several years to implement, but will achieve fastest mass removal.**

A0CXEDJB:
The transport risk is slight and this needs to be clarified.

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Implementability	**HIGH** This alternative is easily implementable.	**MODERATE-HIGH** Implementation requires use of well understood design and installation practices. Additionally, modification of current SVE system would be needed to treat vapors. There are no space constraints for the conveyance piping and treatment compound; however, two GCWs would be in the Goodyear Financial Center parking lot. Significant operation and maintenance effort would be required to keep these wells running, especially since fouling is likely due to high hardness of water. **This requires less drilling than other alternatives, but requires more piping an ex-situ treatment.**	**MODERATE** This alternative is implementable with minimal disruption to locations outside of the treatment area. Injections of electron donor would be injected into 64 locations over a 5-year period. Installation of 9 groundwater monitoring wells would be required to augment the existing groundwater well network. Can be implemented using well-established best practices. Distribution of electron donor may need to be enhanced through use of hydraulic fracturing to overcome variability in stratigraphy. **The alternative will require significant drilling. Permitting issue with bioaugmentation?**	**MODERATE-HIGH** This alternative is implementable with minimal disruption to locations outside of the treatment area. Injections would be achieved using a jet-assisted method to achieve appropriate distribution of nZVI and mZVI particles and ARD amendments as proven in the Phase III Pilot Test. Optimization of the injection delivery system is warranted and would be performed as necessary during execution of each injection phase. Injections would occur in 60 locations over a 5-year period. Installation of 11 groundwater monitoring wells would be required to augment the existing groundwater well network. **Relative to ARD alone, this alternative has the added difficulty of managing the nZVI to avoid agglomeration and to distribute the material.** **However, granular or ZVI in the form of filings is injected as a slurry which creates the need for higher weight tolerance and wear on the equipment and staff.**	**MODERATE-HIGH** This alternative is implementable with minimal disruption to locations outside of the treatment area. Hydraulic fracturing is likely to be required to achieve appropriate distribution of ZVI particles and ARD amendments and create the treatment zones necessary to intercept and treat TCE and perchlorate mass flux. Injections would occur in 105 locations over a 5-year period. Installation of 9 groundwater monitoring wells would be required to augment the existing groundwater well network. **Similar to Alternative 4 but slightly easier to manage ZVI than nZVI.** **However, granular or ZVI in the form of filings is injected as a slurry which creates the need for higher weight tolerance and wear on the equipment and staff.**	**HIGH** This alternative is implementable with minimal disruption to locations outside of the treatment area. Hydraulic fracturing is likely to be required to achieve appropriate distribution of permanganate as a concentrate. Injections would occur in 70 locations over a 5-year period. Installation of 9 groundwater monitoring wells would be required to augment the existing groundwater well network. **Easier to handle and implement as only one amendment needed. Injection permit?** **Will require filing notice with the Department of Homeland Security for storage and management of large quantities. Off-site storage will be necessary and the oxidant will need to be transported via City of Goodyear Streets to the site for injection. .**	**LOW-MODERATE** In-situ thermal technologies and groundwater hydraulic control systems have been installed and operated for many years by a number of contractors, although few ERH applications of this size and depth have been completed. This size and depth of this system will significantly increase the cost and complexity of the heating system. Additionally, the geology at the site has high hydraulic conductivity gradients which may affect the ability of the in-situ thermal heating to achieve boiling temperatures. The above ground surface features and infrastructure would be relatively unaffected; however, any underground utilities would need to be rerouted. For thermal treatment, capacity issues that may arise would be minimized by starting up the thermal system in phases to confirm the VOC mass removal rates can be adequately treated per the design. **Requires above-ground treatment and cabling/piping significant power supply.**

A0CXEDJB:
Permitting issues exist for Alt 4, 5.

A0CXEDJB:
Again, this is a minor issue. There may be injection permitting issues for ISCO, too.

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Cost	**HIGH** No capital or O&M costs would be incurred; however, the costs and negative impacts inherent in opposition from the USEPA and the community members can be considered significant, although non-quantifiable. Not treating the Main Dry Wells Source Area will result in extended operation and maintenance costs for the pump and treat systems currently operating to control migration of the extended plume.	**MODERATE-HIGH** Total costs (-30% to +50%): $5.37MM to $11.51MM Average Capital Costs: $5.16MM NPV O&M Costs: $1.54MM over 20 years Average Closure Costs: $0.98MM	**MODERATE-HIGH** Total costs (-30% to +50%): $6.37MM to $13.65MM Average Capital Costs: $7.43MM NPV O&M Costs: $0.82MM over 3 years Average Closure Costs: $0.85MM	**LOW-MODERATE** Total costs (-30% to +50%): $8.49MM to $18.20MM Average Capital Costs: $10.50MM NPV O&M Costs: $0.82MM over 3 years Average Closure Costs: $0.81MM **Same cost range as ZVI alternative.**	**LOW-MODERATE** Total costs (-30% to +50%): $9.30MM to $19.92MM Average Capital Costs: $11.25MM NPV O&M Costs: $0.82MM over 3 years Average Closure Costs: $1.21MM	**MODERATE-HIGH** Total costs (-30% to +50%): $4.21MM to $9.02MM Average Capital Costs: $4.96MM NPV O&M Costs: $0.82MM over 3 years Average Closure Costs: $0.24MM	**LOW** Total costs (-30% to +50%): $62.26MM to $232.65MM Average Capital Costs: $37.91MM O&M Costs: $84.11MM over 4 years Average Closure Costs: $12.62MM
State and Federal Acceptance							
Community Acceptance							

United States Environmental Protection Agency

Agency Comment Table

Report Titled, "DRAFT Source Area Remediation Focused Feasibility Study (Draft SARFFS Report) Response to Comments Phoenix-Goodyear Airport-North Superfund Site Goodyear, Arizona" Submitted by Haley & Aldrich on 22 May 2012

Phoenix-Goodyear Airport North Superfund Site

Comment Number	Reviewer(s)	Section(s)	Page(s)	Figure(s)	Table(s)	Comment	Response
General (Gen-) Comments							
Major (Maj-) Comments							
Maj-10				---	---	For clarification, please identify that the volumes proposed for ARD, nZVI, ZVI, and ISCO are proposed for costing purposes only, and do not represent final volumes for rememdiation. Final volumes for amendments are to be determined based on site specific sampling during investigation and evaluation phases, and remediation will not be considered complete until the remdial action objectives have been acheived.	We concur. The text will be updated to reflect this change.
Maj-13						We will concur on the assumed spacing for the electrodes, however, the assumed duration of heating for each phase (6-10 months) is longer than times derived from personal experience, and longer than the vast majority of the durations reported in the ESTCP report (Kingston et al., 2010). In Table 13 of that reference 38 of 40 sites the duration of operations were less than 6 months (where duration was reported).	While it is true that most sites report durations as less than 6 months for active, those applications were significantly smaller than the application in discussion and were not much less than 6 months. The duration timeframe of a project is based on many variables with the two most important variables being temperature and hydraulic control. The site has many variables that have not been completed at many in-situ thermal applications including a large areal footprint, greater than 100 feet remediation depth, and high groundwater velocities in certain zones. Based on these variables, it is expected that more time would be needed to get sufficient heating in the target treatment zone in order to have a successful remediation; thus a 6- to 10-month timeframe was selected, with most likely costs set for 6 months and the high costs set for 10 months of operation. These timeframes include the system shakedown and cooldown periods, which together could be up to an additional four weeks of time.
Maj-21						We agree that there are many successful in-situ bioremediation sites, but still believe that the risks are greater at sites without evidence of biologically driven reductive dechlorination. The need for bioaugmentation means that you have two amendments that have to be distributed widely in a large heterogeneous treatment volume. The text should state that this task may be difficult to implement.	The text will be updated to clarify that bioaugmentation will require the injection of an additional amendment. Distribution issues for bioaugmentation culture are unlikely to add to the difficulty of the proposed alternatives. Provided that appropriate geochemical conditions are created by the addition of bioamendment, the bioaugmentation culture will reproduce in-situ, and is capable of colonizing an extensive treatment volume.
Maj-22				---	---	We agree that most of the sulfide should precipitate with iron. The Air Force did have a site in New Mexico with high sulfate that produced excess H2S when the water became anaerobic as a result of a fuel release. However, as it turns out, the sulfate concentrations were about an order of magnitude higher than PGA and are not likely to create a similar situation.	We concur.

Haley & Aldrich, Inc.
4636 E. University Drive
Suite 145
Phoenix, AZ 85034

Tel: 480.308.2700
Fax: 480.966.0439
HaleyAldrich.com

21 May 2012
File No. 37639-011

Arizona and Navajo Section SFD-6-2
Superfund Program
EPA Region 9
75 Hawthorne Street
San Francisco, California 94105

Attn: Ms. Catherine Brown

Subject: Draft Source Area Remediation Focused Feasibility Study Report (Draft SARFFS Report)
Response to Comments
Phoenix-Goodyear Airport-North Superfund Site
Goodyear, Arizona

Dear Ms. Brown:

Haley & Aldrich, Inc. (Haley & Aldrich) prepared this response to comments letter on behalf of Crane Co. These comments were received from the United States Environmental Protection Agency (EPA) on 27 February 2012 and were discussed during the Source Area Remediation Focused Feasibility Study (SARFFS) technical working group meeting attended by the EPA, Arizona Department of Environmental Quality (ADEQ), and other stakeholders on 9 March 2012. The outcome of the technical group meeting discussion was incorporated into the response letter as appropriate and on a comment-by-comment basis.

The purpose of this letter is to document Crane Co.'s response to comments and facilitate a common consensus regarding the content of SARFFS Report Plan.

GENERAL COMMENTS

General Comment No. 1

The study provides a good description of all seven alternatives and the assumed implementation approach is not unreasonable. However, the comparative analysis seems particularly biased and the discussion does not necessarily provide fair and accurate information about some of the alternatives. The scoring for the remedial alternatives needs to be revisited. As an example, the preferences presented here are for technologies that take a highly aerobic site and force it to go to a reduced state, rather than working with nature. The low natural organic content and aerobic conditions would make chemical oxidation a simple choice. While the Draft FFS report emphasizes the disadvantages of some alternatives (preferential pathways and contaminant concentration rebound of permanganate injection), it understates the similar disadvantages for alternatives such as nZVI and ZVI.

Haley & Aldrich will review the comparative analysis and looks forward to working with EPA and other stakeholders to update the scoring of the remedial alternatives within the SARFFS Report. The comparative analysis will be revisited at the scheduled technical meeting on 11 July 2012.

General Comment No. 2
The report also fails to mention and cite examples of applications of the remediation alternatives at sites with similar hydrogeological and geochemical settings. This is important to support a technology where site-specific pilot studies may not have been conducted yet.

Haley & Aldrich will conduct a search for case studies that includes discussion of remediation activities similar to those proposed in the SARFFS Report and are performed in similar hydrogeologic and geochemical settings. These case studies will be referenced in the Revised SARFFS Report to demonstrate the applicability of specific groundwater remediation technologies within the PGA-North Source Area.

General Comment No. 3
A scoring table is attached with an alternate proposed scoring (from 0 to 5). Rationale as to the selection of the scoring criteria is included in the table.

The Crane Co. team is currently discussing the rescoring of the remediation alternatives and the referenced scoring table with EPA and other stakeholders. Haley & Aldrich anticipates that the scoring table included in the Draft SARFFS Report will be updated following receipt, review, and evaluation of the analytical results of the PGA-North Source Area source area groundwater sampling event, conducted during the week of 30 April 2012. It will be discussed further at the meeting on 11 July 2012.

General Comment No. 4
Two or three technologies that work together over a period of time should be evaluated. For example, ZVI applied directly in the source zone, followed by ARD after confirmation that the COCs are no longer at levels considered toxic by the bacteria, followed by additional electron donor addition is one example. The selected technologies do not have to work independently at a single point in time (or phase approach of the same technology) to be considered. Additional discussion with the Agency team to develop additional combinations of process alternatives is recommended.

The 9 March 2012 SARFFS technical working group meeting included discussion of sequenced or phased application of remediation technologies. The remediation alternatives currently included in the draft SARFFS are designed to be applied in phases where necessary. With respect to EPA's example, it is not atypical to co-inject nano-scale zero valent iron (nZVI) and electron donor in areas with high volatile organic compound (VOC) concentrations. In fact, co-injection of nZVI and electron donor has been shown to accelerate the mass degradation rates at many sites, nationwide, where groundwater is impacted with high concentrations of chloroethenes. The local hydrogeology and site conditions do not preclude the use of this approach in the PGA-North Source Area. Case studies for application of this technology in this manner will be included in the SARFFS Report. Haley & Aldrich anticipates additional discussion on this topic and other possible sequencing options at the next SARFFS technical working group meeting.

General Comment No. 5
The network of new proposed monitoring wells is not adequate to monitor the progress of the treatment alternatives, especially for the alternatives in which the media is injected as a series of barriers. Additional monitoring wells should be installed between the barriers.

EPA's comment is noted. Performance monitoring wells will be added as necessary during the design phase of the chosen remedy. Since quantity and location of the monitoring wells was not a major cost or design factor, the proposed number of monitoring wells in the SARFFS Report for each alternative was selected for consistency between the different alternatives.

MAJOR COMMENTS

Major Comment No. 1:
Section 1.2.3.3, Page 7. "Subunit B" The lack of a clear Subunit B in MW-28 and EPA MW-40C is not necessarily due to a failure to recognize B during logging. Subunit B across the site is not well understood, and there are several areas where Subunit B has not been seen. Additional investigation into Subunit B, its physical and hydrogeological properties, and its role and function in the source area (estimate of TCE concentrations contained with SubUnit B) in relation to any selected technology will be necessary prior to implementation of a treatment in the source area.

Haley & Aldrich concurs that Subunit B is not currently well understood. A Subunit C investigation is currently underway in the area south of Interstate 10 (I-10) to refine our understanding of the Subunit A, Subunit B, and Subunit C aquifer units. A total of four Subunit C wells (EPA MW-4C, EPA MW-13C, EPA MW-19C, and EPA MW-27C) are anticipated to be drilled in this area using rotosonic drilling methodology. This will allow for the collection of soil cores to accurately identify the thickness and grain size distribution within each subunit. Additionally, depth specific groundwater samples will be collected within each subunit to identify the trichloroethylene (TCE) distribution with depth, and physical property samples will be collected at discrete intervals within the extracted core from Subunit B for analysis of horizontal and vertical hydraulic conductivity, porosity, density, and grain size analysis. This information will also be used to refine the Focused Box Contaminant Transport Model (Item No. 29 on the May 8, 2012, 2012 PGA-N Deliverables Tracking Table) which is being constructed to evaluate the TCE migration from Subunit A to Subunit C at the Main Drywells Source Area (MDWSA).

Major Comment No. 2:
Section 1.2.4, Page 9. Please add that vapor intrusion issues were considered and that indoor-air sampling had been previously conducted and no significant risk was identified.

This information will be added to this section.

Major Comment No. 3:
Section 1.3.7, Page 12. The Phase III Pilot Test results have not been approved by EPA. Comments on the pilot test were generated and sent to Crane Co. on May 10, 2011. These comments have been attached to this review, and outline the concerns regarding the conclusions, primarily that there was significant rebounding seen in most if not all of the monitoring wells within a short period after the injections, and no follow up soil sampling to provide data on subsurface distribution of the iron particles. In some cases the concentrations after the injections exceeded the concentrations seen during the baseline sampling event.

Additional discussion is ongoing regarding the results of the Phase III Pilot Test and their implications with regards to the feasibility of the nZVI alternative. Significant rebounding was anticipated because the pilot test was conducted in a very limited area within the MDWSA. The TCE present in the larger environment surrounding the pilot test area is likely the source of the rebound in TCE concentrations. The first phase of remedy implementation includes follow-up soil sampling, optimization of the jet-assisted injection tooling, research into the use of a suspension agent, and determination of the orientation of the injection jet nozzles. This information will be added to the description of this alternative in the Revised SARFFS Report.

Major Comment No. 4:
Table 2 is challenging to evaluate as it currently stands. While there is a reasonable if abbreviated discussion of the technical approach, effectiveness and implementability, there is no discussion as to why a process option was eliminated or retained, and there was no effort to combine technologies in such a way as to mitigate limitations that may exist with one technology, but when used in combination with another technology, might have a higher degree of success. For example, pump and treat was eliminated from further consideration, but with no rationale provided as to why it was eliminated. One limitation mentioned was the issue of low permeability zones. This limitation can be overcome by considering hydraulic or pneumatic fracturing to increase the permeability thus enhancing the potential for significant mass removal. All process options require a discussion as to the rationale of why the process option was retained or eliminated to allow for complete evaluation of this section. Please provide so a complete evaluation by the stakeholders can be completed.

A rationale for retaining or eliminating of process option(s) will be included in this table.

Major Comment No. 5:
Section 2.4.3, Page 16. A passive (macro) ZVI barrier system could be placed using the Geosierra system of vertical fracturing, assuming that adequate pressures could be generated to create vertical fractures between holes in the more permeable zones. Please mention and evaluate that technology.

EPA's comment is noted. As pointed out in Table 2, a permeable reactive barrier (PRB) would not meet the Remedial Action Objectives (RAOs), as defined in EPA's email, dated 21 October 2011. Specifically, a PRB would not remove 80% of the mass and 80% of VOC concentrations within the source area. This would be due to its placement downgradient of the source area to intercept migration of mass in groundwater from the source area. Therefore, further evaluation of this technology is not warranted. Haley & Aldrich will add additional rationale to Table 2 to provide a better understanding of the basis for the remedial alternatives screening.

Major Comment No. 6:
Section 2.4.7, Page 18. Please delete "with Steam" from the title, as this is not what was really evaluated. If thermal was the selected remedial technology, a reasonable approach would be to recommend a performance goal, and let the vendors craft an approach that would take into account the subsurface heterogeneity and relatively conductive ground water.

As requested, "with Steam" will be deleted from the title.

<u>*Major Comment No. 7:*</u>
Section 3.2.3, Page 21. The statement that existing extraction wells along Van Buren Street provide an effective hydraulic barrier is not confirmed by all stakeholders. In order to demonstrate capture, multiple lines of evidence are required, at this time, the only evidence for capture along Van Buren Street has been provided by the model. Multiple lines of evidence for complete capture will be necessary to definitely demonstrate that the Van Buren Street hydraulic barrier would perform as this text indicates.

The Draft Subunit A Capture Zone Report EA-05/EA-06, EA-07, 33A and Source Zone Capture Zone Update Memo submitted on 23 September 2011 evaluated multiple lines of evidence to determine that the Main Treatment System (MTS) extraction wells are providing complete capture of the plume up to West Van Buren Street. As such, the existing extraction well network associated with the MTS will be able to provide an effective hydraulic barrier to work in conjunction with the in-situ treatment technology.

Matrix New World Engineering is scheduled to submit a Work Plan during Second Quarter 2012 to install an additional extraction well (EA-09) which will help enhance the already effective hydraulic barrier associated with the MTS. Additionally, extraction well EA-01 has recently been rehabilitated and EA-02 will be undergoing rehabilitation in the near future to increase groundwater extraction rates and enhance plume capture. New piping is currently being installed from EA-02 to the MTS to allow a significant increase in pumping to be achieved at this well.

<u>*Major Comment No. 8:*</u>
Section 3.2.3, Page 22, Table 4. a) The area assumed here (250 ft by 700 ft = 175,000 sq ft) would represent about half of the area targeted as stated in section 2.3 (350,000 sq ft). Yet the number of IWAS wells (17) and assumed radius of influence (100 feet) would suggest a treatment area of over 500,000 sq ft. Please reconcile. b) The technology does not necessarily need a surface/external air stripper. The original UVB or ART wells use aeration in the well itself and achieve comparable removal efficiencies to those mentioned here.

EPA's comment is noted. In response, the following information will be added to the referenced table or section as appropriate:

a) The number of in-well air stripping (IWAS) wells was increased to provide overlapping coverage of the treatment area in the case that complete recirculation is not achieved as expected given the heterogeneity of Subunit A.
b) While it is true that the original UVB or ART well typically did not include an external air stripper, the vendor in this case thought it would be necessary to have an ex-situ treatment unit due to the high concentrations of target compounds in site groundwater. The external air-stripper would allow for improved VOC removal efficiency before the groundwater is reinjected to Subunit A.

<u>*Major Comment No. 9:*</u>
Section 3.2.4, Page 25, Table 5. a) Please provide the basis of design for the injection well spacing, injection line spacing, and lift spacing. b) Please provide the basis for the volume of microbial culture selected. c) Please provide the basis and justification for the phased approach; with a system that requires a longer treatment time, such as ARD, it would be advisable to provide the maximum amount of microbial culture as early in the process as possible.

The following detail, corresponding to each item, will be provided in this section.

a) The injection spacing is based upon the radius of influence measured from the Phase III Pilot Test.
b) The volume of microbial culture is based upon the following factors: anticipated volume within the radius of influence of injection, the doubling rate of growth for the bacterial population, and the timeframe needed to see results. The volume used for this alternative was based on past experience at other remediation sites and the vendor's recommendation, who in this case was SiREM Laboratory, Inc.
c) Implementation of the Triad approach during implementation of the remedy requires that time be built into the process in order to allow for: identification of injection intervals based on the concentrations measured using boring installations; development and real-time adjustment to the potential mobilization of mass during injection activities; calculation of dosages in accordance with the VOC concentrations detected from the Triad hydropunch samples; soil types identified in the borings; and optimization and adjustment of the chosen remedy on a real-time basis.

Major Comment No. 10:
Section 3.2.5, Pages 26-27, Table 6. a) There is not sufficient data from the pilot test to evaluate potential further delivery. Soil sampling results will be necessary to confirm the radius of influence and distribution of nZVI seen in the pilot test. b) Pilot test chemistry results indicated in some areas that the rebound concentrations exceeded the baseline concentrations. This was likely due to mass being released from a low permeability zone during the jet assisted injection procedure. Please demonstrate how the stoichiometry calculations have been adjusted to allow for the likely potential of these higher concentrations throughout the treatment zone. This calculation will also have an effect on the cost evaluations. c) Please indicate what the spacing would be for any injection lines. d) Please provide the basis and justification for the design assumptions. e) Please clarify that the depth specific intervals will be determined based on the lithology of the injection well. f) Please explain the optimization criteria for the orientation of the injection nozzles. The orientation of any fracturing would have to be planned and measured.

EPA's comment is noted. Please note that the nZVI dosage was not adjusted because there is no evidence that the dosage was insufficient. In response to EPA's comment, the following information, corresponding to each item, will be added to the referenced table or section as appropriate:

a) The stoichiometric calculations for the nZVI + Anaerobic Reductive Dechlorination (ARD) alternative (Alternative 4) were based upon an anticipated maximum TCE concentration of 12 milligrams per liter (mg/L) throughout the treatment volume, a sulfate concentration of 800 mg/L, and an oxygen concentration of 4 mg/L within a 25-foot radius of influence, with the assumption of a 30% porosity. On a stoichiometric basis, the sulfate exerts 96% of the total demand, with nitrate and TCE exerting 2.4% and 0.7% of the total demand, respectively. The highest concentration of TCE detected during pilot test performance monitoring was 7.8 mg/L and was detected in groundwater from IRZ-IW-01 on 6 August 6 2010. TCE was detected at 46 micrograms per liter (μg/L) in groundwater from MW-B during the pre-injection baseline monitoring event. Considering these factors and the variability of the TCE concentration within the Subunit A groundwater within the pilot test area, the nZVI concentration was sufficient to address TCE concentrations present in the pilot test area.
b) It is likely that TCE mass was mobilized during the physical act of groundwater displacement due to the injections. Note that the jet-assisted injection method is comprised of two stages; during the first stage, the high pressure pump is used to create holes in the injection well casing

with water. The first high-pressure injection is more likely to disturb and mobilize mass due to the high pressure and potential for high disturbance of the formation. It is more likely that the injection of water under high pressure was responsible for the mobilization of mass than the injection of the nZVI.

c) The spacing of the injection lines are intended to be the same as the cross-gradient distance between the injection points, which is 60 feet.
d) Design assumptions were based upon the Phase III pilot test results and upon our current conceptual site model, which includes a basic understanding of the distribution of TCE mass within Subunit A. The injection depths were assumed to be the same for each alternative that involved direct injection in order to provide a direct comparison. The design parameters will likely be refined during the design phase of the remedy.
e) The specific injection depth intervals will be based upon the detection of TCE in groundwater samples collected during hydropunch activities conducted as part of the Triad approach.
f) Optimization criteria for the orientation of the nozzles will be developed in the Work Plan for the full-scale remedy. These criteria will be, in part, based upon the strength and configuration limitations of the available tooling and the optimal distribution to be achieved within those constraints.

Major Comment No. 11:
Section 3.2.6, Pages 28-29, Table 7. a)How much of the "1500 lbs of mixture per injection point" is ZVI? Please state this. b) Pilot test chemistry results indicated in some areas that the rebound concentrations exceeded the baseline concentrations. This was likely due to mass being released from a low permeability zone during the jet assisted injection procedure, a phenomenon that will likely occur with the proposed fracture and injection technology proposed with this process option. Please demonstrate how the stoichiometry calculations have been adjusted to allow for the likely potential of these higher concentrations throughout the treatment zone. This calculation will also have an effect on the cost evaluations. c) Provide the basis for the recommended volume of DHC. d) provide the rationale as to why only a barrier configuration was considered, a grid system would also work with this technology and should be evaluated.

Our response to each corresponding item is provided below:

a) "1,400 pounds of the 1,500 pounds of the injection mixture is nZVI" will be added to the referenced table or section as appropriate.
b) See response Comment No. 10.
c) See response for Comment No. 9
d) "This alternative was proposed in a barrier configuration due to the longevity of the ZVI, and the impracticality of the injection spacing if the remedy were to be implemented in a gridded configuration. The injection spacing would need to be 10 feet or less due to the injection characteristics of the ZVI particulate slurry." will be added to the referenced table or section as appropriate.

Major Comment No. 12:
Section 3.2.7, Page 30, Table 8. 1,735,000 gallons of water and 290,000 lbs of permanganate would work out to about 20 g/L of permanganate. Diluting this into the volume of water in the pores of the treatment area would yield under 1 mg/L (1000 mg of permanganate/L). It takes about 2 grams of permanganate to react with a gram of TCE (ITRC ISCO Technical Regulatory Guidance, 2005, pg 6,

Table 1- 2). So, this would assume treatment for an average dissolved TCE concentration of under 500 mg/L, not counting what is sorbed, or possibly hiding as sparse, residual, and immobile NAPL, and doesn't account for the natural oxidizable organic material. Please provide the basis for the 290,000 lbs.

The basis for the 290,000 pounds of permanganate will be added as an appendix to the SARFFS Report.

Major Comment No. 13:
Section 3.2.8, Page 32, Table 9. a) The thickness of the treatment zone is 100 feet, rather than the 60 feet assumed for the other alternatives. Although it is appropriate to account for creation of a "hot floor" to minimize vertical migration, the added 40 feet is probably unnecessarily large. Only in the main dry wells source area would increased treatment thickness possibly be necessary. b) The spacing for the electrodes seems tight, please clarify that this spacing was provided by the vendor. c) The monitoring network will require thermistors/thermocouples to monitor temperature. I didn't see those in the table for monitoring, please adjust costs accordingly. d) The assumed duration for each location seems quite long for TCE treatment if it only includes the actual heating. If it includes set-up, etc., then perhaps it's more realistic, please clarify.

The basis of the thermal remediation alternative includes the possible use of steam injection wells in the high concentration area. Based on the process of thermal heating and the geology within this treatment area, the 100-foot thickness is expected to be within approximately 10 feet of the actual thicknesses, as the use of steam wells requires additional vertical thickness to properly heat the base of the treatment zone. This treatment zone would include a hot floor approximately 10 feet thick below the area of highest concentrations, which in specific and limited locations occur at approximately 170 feet. In some areas the treatment area would include heating 10 feet above the 90-foot depth to water to minimize heat losses at the top of the treatment zone and minimize condensation of contaminants at the water table. This thickness may be decreased if only electrodes are used for heating the thermal treatment area, and will be decreased if contaminants only reach 150 feet.

The spacing of the electrodes is based on average electrode spacing used on recent state-of-the-art thermal applications for application of similar geology (ESTCP, 2010). The actual spacing of the electrodes will be decided in the final design of the system if a thermal remediation system was installed.

The monitoring network would include pressure and temperature monitoring devices. The cost for this monitoring is already included in the costs.

The assumed time frame for thermal treatment is based on similar applications for chlorinated solvents in large treatment areas. The time frame does not include system set-up, but does include the system shakedown. It also assumes that each phase will include a sequenced startup where only portions of the system will be initially operated to check the above ground equipment and allow time for the hot floor to be established within in each treatment train. This sequenced startup will allow for additional monitoring to watch for flow from other treatment zones into the operational zone.

<u>*Major Comment No. 14:*</u>
Section 3.3.1.1, Page 33. a) The sustainability of each alternative is not discussed under "Overall Protection of Human Health"; only for alternative 2. Please mention the results for each alternative under long-term effectiveness or reduction in toxicity, volume, mobility. b) The in-well air stripping is meant to be used at heterogeneous sites as you need some layering to result in a larger recirculation cell. Heterogeneity is not to be considered a limitation. c) The persistence of all amendments must be considered. The statement about the persistence of the permanganate would also apply to the alternatives that involve emulsified oil. The stakeholders need to be informed about the resulting anaerobic water that would be created under Alternatives 3-5 and would persist for some potentially long period of time.

EPA's comment is noted. Please see our response to each corresponding item below:

a) A discussion of the sustainability of each alternative will be added to the section addressing the long-term effectiveness or reduction in toxicity volume, and mobility.
b) Haley & Aldrich understands that heterogeneity provides some advantages and disadvantages relative to the size and completion of the recirculation cell. These advantages and disadvantages will be more comprehensively described in this section.
c) A discussion of the longevity of anaerobic water will be added to the discussion of Alternatives 3, 4, and 5.

<u>*Major Comment No. 15:*</u>
Section 3.3.1.3, Page 34. a) The IWAS recirculation cell would result in a greater reduction than implied by the 45% recirculation rate. One needs to look at the effective concentration given that at least some of the water has been cycled more than once. b) Rebound is much less likely for in-situ thermal remediation than for bioremediation and ISCO. c) There is a real possibility that there will be incomplete contact between the contaminant and the treatment media for alternatives 3 and 4 due to the means of placement and particularly the longevity of the nZVI in Alternative 4. d) Multiple injections of the oxidant are the norm, not the exception. The ISCO alternative should assume some additional injections in some subareas of the target zone. This will affect the cost considerations, please adjust accordingly.

EPA's comment is noted. Please see our response to each corresponding item below:

a) Haley & Aldrich has included the reduced concentrations with the assumption that 45% of the water may be recirculated.
b) We concur. This observation will be added to this section.
c) We concur. It is commonly understood that no injection method can achieve complete contact.
d) Follow-up injections are assumed in this alternative and included in the conceptual design for the alternative presented in the draft SARFFS Report. A comment to this effect will be added to this section.

<u>*Major Comment No. 16:*</u>
Section 3.3.1.4, Page 35. Alternative 4 (ARD with nZVI) would likely not result in the highest reduction in toxicity or volume. Alternative 7 would likely have the highest removal as it is not limited by the heterogeneity of permeability, however, it would not address perchlorate.

We concur - especially as compared to thermal remediation.

<u>*Major Comment No. 17:*</u>
Section 3.3.1.5, Page 35. The distribution of nZVI or ZVI would be the determining factor to success in either of these methods. The proposed analysis needs to better acknowledge this uncertainty as at this time there is no data to confirm the distribution of the nZVI from the Phase III Pilot testing, and ZVI has not been utilized at the site.

Haley & Aldrich concurs that there is uncertainty regarding the pattern of nZVI distribution resulting from jet-assisted injection. A comment to this effect will be added to this section.

<u>*Major Comment No. 18:*</u>
Section 3.3.1.6, Page 36. a) For any of the ARD alternatives, but particularly for Alternative 3, it would be necessary to stage the injection such that the carbon source would be injected first, allowing the system to go anaerobic. The bioaugmentation would have to occur later, after the conditions are right for the dehalococcoides, otherwise, the bugs will potentially experience an unacceptably large die off. b) It is not clear how, with alternative 4, you would "ensure distribution of the injectate is adequate." Note that there is a potential ground shift at the surface (though not too likely). This may be a problem near the parking lots. c) Depth should not be a limitation for the in-situ thermal methods. Literature presents applications to 100 feet, and there is no reason why the active electrodes could not be placed deeper than that.

a) The necessity for an acclimation period during which the carbon source would be utilized by aerobic and anaerobic microorganisms, resulting in the creation of anoxic and reducing conditions, will be assessed during the design phase of the project. There have been bioremediation applications where augmentation has been performed at the same time as carbon source injection, where the culture has been injected within anaerobic amendment solution to prevent exposure to oxygen in the subsurface. This technique would only be used at PGA-North if conditions in the deeper portions of Subunit A are reducing. Otherwise, the existing injection wells can be used for bioaugmentation after subsurface anaerobic and reducing conditions are confirmed. Additional information will be provided to offer a more explicit discussion of this issue.
b) This section will be revised to state that the distribution of injectates will be monitored in groundwater from performance monitoring wells that are specifically located for this purpose.
c) A statement will be added to clarify the limitation referred to in this section with regard to thermal remediation is electricity, not necessarily electrode depth.

<u>*Major Comment No. 19:*</u>
Section 3.3.1.7, Page 36. The text states that the cost estimates were developed in accordance with USEPA guidance without stating which guidance was followed. The guidance provided in the reference which would be relevant to cost estimate preparation and evaluation would be the October 1998 "Guidance for Conducting Remedial Investigations and Feasibility Studies under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)". This is an outdated reference for evaluating costs in a feasibility study. Please update the cost evaluation to be conducted in accordance with EPA's July 2000 guidance "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study". It was very difficult to fully evaluate the costs provided in the Draft SAFFS since the backup was not provided. As noted in this guidance, the next cost estimate must include all of the detailed backup, including but not limited to cost calculation sheets, quantity calculation sheets, records of communication with vendors for quotes, and conceptual design calculations.

Pursuant to our discussion during the 9 March 2012 SARFFS technical working group meeting, Haley & Aldrich will provide the detailed back up for the cost estimates included in the draft SARFFS.

<u>*Major Comment No. 20:*</u>
Sections 3.3.1.8 and 3.3.1.9, Page 38. You cannot, at this point, assume or endorse Public acceptance. This is to be determined with the publication of the proposed plan.

We concur. The ratings for public acceptance will be removed from the table.

<u>*Major Comment No. 21:*</u>
Section 3.4.1, Page 40. Alternative 3 ARD. Rebound is a possibility with this alternative, contrary to what is stated here. The high sulfate and need for bioaugmentation makes this alternative a relatively high risk for success compared to other alternatives.

Section 3.4.1 page 42 includes a reference to the presence of high sulfate and how it will increase the necessary dosage of amendment. A discussion of the impacts of the high sulfate concentrations and groundwater velocity on the successful implementation of ARD in the source area will be added. Please note that for this reason, the rating for the implementability of this alternative is a 2 on a scale of 0-5 for this alternative. However, the need for bioaugmentation added low, not high, risk to the success of this alternative. Bioaugmentation has been performed successfully at many sites where the prevailing initial reduction-oxidation conditions are aerobic and oxidative. The need for bioaugmentation entails additional effort in the design and implementation phases of the remedy, but does not highly increase the risk of failure.

<u>*Major Comment No. 22:*</u>
Section 3.4.1, Page 42. Alternative 6. Again, the anaerobic conditions would persist for some significant time following ARD as well – and the water would be a significant source of hydrogen sulfide, given the high sulfate content. Alternative 7. The replacement cost for the SVE system would be minor compared to the other costs associated with this alternative. Note that this alternative has the highest likelihood of attaining the goals.

With regards to Alternative 6, we concur that the reduction of sulfate to sulfide would result from the addition of a carbon substrate to Subunit A. However, precipitation of hydrogen sulfide with ferrous iron would likely occur very quickly, resulting in the formation of iron sulfide (FeS) precipitate. FeS would drop out of solution to take residence in the formation before the groundwater could reach a downgradient extraction well. This phenomenon is evident at many bioremediation sites where sulfate is being reduced to sulfide, but low to non-detected concentrations of sulfide are detected in groundwater due to precipitation with ferrous iron which is also mobilized under reducing conditions.

With respect to Alternative 7, we concur that the replacement cost for the soil vapor extraction (SVE) system would be minor compared to the cost of implementing thermal remediation in the source area. We also concur that this alternative has the highest likelihood of attaining RAOs.

Major Comment No. 23:
Appendix D. During the November 2011 Quarterly Meeting, a discussion was held regarding the evaluation of sustainable remediation practices. At that time, although the Crane Team made a proposal to use a proprietary software developed by Haley & Aldrich, the Agency Team indicated that an EPA-approved tool should be used. One source of information for this would be EPA's April 2008 document entitled "Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites", EPA 542-R-08-002.

At the time the draft SARFFS Report was submitted to the EPA, an EPA-approved sustainability evaluation tool was not available; therefore, the tool developed by Haley & Aldrich was presented to the EPA at the November 2011 Quarterly meeting and was subsequently used in the SARFFS Report.

If you have any questions regarding the contents of this response, please contact me.

Sincerely yours,
HALEY & ALDRICH, INC.

Paula R. Chang
Remediation Program Manager

Attachments

c:

CH2M Hill; Attn: Phillip C. Whitmore (electronic)
CH2M Hill; Attn: Leanne Austrins, (electronic)
ADEQ; Attn: Nicole Coronado, (electronic)
ADEQ; Attn: Joellen Meitl, (electronic)
ITSI; Attn: Nancy Nesky, (electronic)
ITSI; Attn: Dr. Ailiang Gu, (electronic)
Crane Co.; Attn: Dr. Anthony Pantaleoni, (electronic)
Environmental Venture Group; Attn: Alan F. Bilzi, (electronic)
US Army Corps of Engineers; Attn: David J. Becker (electronic)
Clear Creek Associates; Attn: Tom Suriano (electronic)
Matrix New World; Attn: Harry Brenton (electronic)
AMEC; Attn: Stephanie Koehne (electronic)

Agency Comment Table
Report Titled, "DRAFT Source Area Remediation Focused Feasibility Study (SARFFS)" Submitted by Haley & Aldrich
Phoenix-Goodyear Airport North Superfund Site

Comment Number	Section(s)	Page (s)	Figure (s)	Table (s)	Comment	Response
Minor (Min-) Comments						
Min-1	2.4.1	15-16	---	---	The SAFFS report should not assume that the MTS will be the appropriate treatment in a pump and treat technology application; other technologies should be considered for treatment of extracted water.	Other ex-situ treatment technologies would be considered if necessary to achieve treatment requirements.
Min-2	1.3.3	11			Reduction in concentration at injection wells is not commonly accepted as proof of successful remedial application.	We concur.
Min-3	1.3.5	11			It is important to understand the travel distance of the nZVI in the column testing, please add this information to the text.	The travel distance of the nZVI in the columns will be added to the text in this section.
Min-4	1.3.6	11			Please clarify which chemistry results indicated that the nZVI mass was still active at 22 weeks. This is quite an aggressive timeframe for seeing persistence of the nZVI.	The text states that elevated hydrogen concentrations were detected 22 weeks after injection of nZVI.
Min-5	2.4	15			It would be helpful to provide literature references for sites where the proposed technologies have been used, either successfully or unsuccessfully. This is consistent with the EPA guidance on preparation of Feasibility Studies.	Literature references for case studies where the proposed technologies have been used will be added to the text where appropriate.
Min-6	2.4.1	16			Note that with air sparging, one could amend the air with a co-metabolite such as methane, though it would still suffer from the limitations of heterogeneity. A brief mention of the potential addition of this amendment in the text would suffice.	We concur. The potential for biological enhancement of air sparging by adding a cometabolite such as methane and a brief discussion of its limitations will be added to the text.
Min-7	2.4.4	17			The past testing of dithionate solutions as a chemical reductant should be included. This was attempted at least two locations – the Hanford DOE site and Ft. Lewis both in Washington state. The results were disappointing, this technique is not recommended, but should be mentioned as having been considered.	Agreed. This method and the results from the two sites you mention will be added to the text.
Min-8	2.4.5	18			Second bullet. Application of permanganate solutions can result in the formation of manganese oxides, not permanganate solids (as stated in the text). In the case of one vendor, they actually use the formation of the Mn oxides to encapsulate contaminants.	We concur. The text will be updated to reflect this change.
Min-9	2.4.8	19			The extent to which a technology has been bench scale and pilot tested at the PGA North site is not a sound argument for accepting or rejecting a specific technology. Cases studies, bench scale and pilot studies from other similar sites should be used as a resource in the to help determine the effectiveness of technologies.	The purpose of pilot testing a remediation technology is to determine effectiveness and in many cases determine which design parameters can be optimized for better performance. The successful implementation of a remediation under field conditions through successive tests is typically a very strong argument to support full-scale utilization of that technology, especially if test objectives have been met. We will add relevant groundwater remediation case studies from other sites, as available, and deemed applicable to conditions at this site.

Agency Comment Table
Report Titled, "DRAFT Source Area Remediation Focused Feasibility Study (SARFFS)" Submitted by Haley & Aldrich
Phoenix-Goodyear Airport North Superfund Site

Comment Number	Section(s)	Page (s)	Figure (s)	Table (s)	Comment	Response
Min-10	3.1.1	33			The argument that ISCO, specifically permanganate would be moderately protective of human health should be reconsidered based on the assumption that the hydraulic barrier would prevent offsite migration. Alternatives 5 (nZVI) whose long-term health effects are unknown relies on the hydraulic barrier to prevent offsite migration according to the text.	There is no section 3.1.1 in the report, therefore the report will be reviewed to see where text changes may be applicable. A discussion of the ERH alternative is located on Page 33. Human health risk becomes an issue if permanganate-laden water is recirculated in the the aboveground water treatment system increasing likelihood for contact with treatment system workers.
Min-11	3.2.8	31-32		9	Alternative 9 (ERH/Steam + Hydraulic Control) did not address the need for performance monitoring of the vapor treatment system.	This alternative assumes that performance monitoring of the vapor treatment system would occur. Text will be added and the costs will be checked to assure that performance monitoring is included in this alternative.
Min-12	3.3.1	33			Alternative 3/4/5 should consider the impact of site heterogeneity and its effect on radius of influence and formation of preferential pathways.	We concur.
Min-13	3.3.1.3	34			In the discussion of Alternative 6 (ISCO/Hydraulic Barrier), its long term effectiveness is questioned due to the potential for rebound and that the injectate is likely to follow preferential pathways. This seems to be an unequal application of criteria in that these were not considered for Alternative 5 which, based on data from pilot testing conducted onsite, is limited by the same parameters.	Macro-scale ZVI (Alternative 5) has not been pilot-tested at the site. If this comment meant to refer to nZVI, there is very little likelihood that nZVI will migrate with groundwater for extended periods of time after injection, whereas, due to the low oxidant demand typical of desert aquifers, permanganate has been demonstrated to migrate with groundwater for hundreds of feet and exhibit a longevity in excess of two years (Tucson Air National Guard Pilot Test). The jet-assisted injection method does not result in migration of injectate along preferential pathways due to the characteristics of the nZVI and the mixing of formation materials with amendment. The mixing that occurrs during injection increases the likelihood of contact which in turn reduces the likelihood of rebound.
Min-14	3.3.1.4	35			The statement that Alternative 4 (nZVI/Hydraulic Barrier) would provide the highest reduction in toxicity and mass reduction is premature given that other alternatives were not tested at the site for effectiveness and case studies from similar sites were not considered in the evaluation.	Case studies for application of the remediation technologies at other sites will be added to the SARFFS to balance the evaluation.
Min-15	3.3.1.5	35			The statement that Alternative 6 (ISCO/Hydraulic Barrier) would only treat readily available contaminant mass due to limited aquifer penetration is dependant on application methodology. ISCO can also be introduced in a similar fashion to nZVI (High pressure fracturing followed by pressure injection). The FFS should evaluate this application option for an equitable comparison to be made.	Application of permanganate using the jet-assisted injection method will be added to this alternative and carried through the detailed evaluation.

Agency Comment Table
Report Titled, “DRAFT Source Area Remediation Focused Feasibility Study (SARFFS)” Submitted by Haley & Aldrich
Phoenix-Goodyear Airport North Superfund Site

Comment Number	Section(s)	Page (s)	Figure (s)	Table (s)	Comment	Response
Min-16	3.4.1	41			Alternative 4. Given that there was no reactivity of nZVI with perchlorate in the bench testing, the statement there is “less effectiveness” for perchlorate is overly optimistic.	There is literature that shows that perchlorate concentrations decrease in the presence of nZVI. This reference will be added to the text.
Min-17	3.4.1	41			Data collected during pilot testing of nZVI indicated that rebound was occurring in the wells monitored as part of the Phase III pilot study and should be included in the discussion of ZVI / nZVI disadvantages.	We concur.
Min-18	3.4.1	42			The SAFFS should consider the use of jet assisted injection of permanganate to reduce limitations due to inadequate mixing in the subsurface and preferential pathways. If permanganate were evaluated using jet assisted injection, these limitations would be eliminate, providing an application scenario similar to nZVI / ZVI alternatives.	Please see response to Min-15.
Editorial (E-) Comments						
None	---	---	---	---		

Chang, Paula

From: Brown.Catherine@epamail.epa.gov
Sent: Friday, October 21, 2011 4:09 PM
To: TPantaleoni@
Cc: 'agu@itsi.com'; 'abilzi@aol.com'; 'bchappell@avondale.org'; 'dave.j.becker@usace.army.mil'; 'dfisher@itsi.com'; Bruck.Glenn@epamail.epa.gov; 'jlittell@brwncald.com'; 'JWright@brwncald.com'; 'Leanne.Austrins@CH2M.com'; 'Matthew.Garlick@LibertyWater.com'; 'NNesky@itsi.com'; 'Nate.Brown@CH2M.com'; 'Coronado.Nicole@azdeq.gov'; Chang, Paula; 'Phillip.Whitmore@CH2M.com'; 'tsuriano@clearcreekassociates.com'; 'tpantaleoni@craneco.com'; 'wjanis@avondale.org'; 'bking@matrixneworld.com'; Daus, Tony; 'DPetrocelli@matrixneworld.com'; 'hbrenton@matrixneworld.com'; Jeffers, Paul; 'mhansen@matrixneworld.com'; Minnier, Gwen E; Panday, Sorab; Patel, Nimisha; 'tdemichele@matrixneworld.com'; 'zmccraw@matrixneworld.com'; 'jerry.postema@goodyearaz.gov'; 'mdempsey@matrixneworld.com'; Jm11@azdeq.gov; Brooks Dillard; Koehne, Stephanie; Trombadore.Claire@epamail.epa.gov

Subject: Comments on SARFFS Draft Technology Matrix for PGA North

Tony,

Thank you for the October 14, 2011 submittal of the ‘Table 1: Preliminary Remedial Technology Screening for the Source Area Focused-Feasibility Study: Former Unidynamics Facility, Goodyear, AZ’. The technology matrix contains appropriate options for evaluation but indicates 'elimination' of options already without providing the screening criteria used or the analysis. Please be advised that all listed remedial alternatives, individually or in combination, should be screened as part of this focused-feasibility study.

In addition, the following remediation technology should be added to the matrix of remedial alternatives:

Technology class: hydraulic barrier / bioremediation

Process Option: groundwater circulation wells.

Technical approach: Installation of a series of wells with dual screens – one above and one below the water table. Air is injected into the well below the water table, aerating the water. The aerated water level rises in the well and flows out the upper well screen into the vadose zone. Groundwater is pumped from the lower screen interval and diverted back down the well annulus out into the vadose zone. Off-gassed VOCs from the well are collected in a soil vapor extraction system. Localized groundwater mounding in the vicinity of the well is created as the partially aerated and mounded water flows back through the aquifer to pumping zone in the lower screen interval.

An additional correction is needed for the statement of the Remedial Action Objectives (RAOs) with Table 1:

1) Achieve permanent mass flux reduction (80% as an initial reduction within an as yet unspecified period of time).
2) Achieve permanent concentration reduction (80% as an initial reduction within an as yet unspecified time).
3) Mass removal within the source area.

Finally, please note that although the effectiveness of perchlorate treatment should be evaluated for each remedial alternative, it should not be considered a primary RAO or viewed as a criteria for eliminating a technology. Recent perchlorate concentration data shows a declining trend throughout the plume other than those areas where plume direction has shifted. Also, the cleanup level is only exceeded in approximately 6 wells. Please include an assessment of the cleanup timeframe for perchlorate in the draft FFS.

EPA looks forward to receiving the draft Source Area Focused-Feasibility Study in 90 days.

Catherine Brown, RPM
Arizona and Navajo Site Section SFD-6-2
Superfund Program
EPA Region 9

75 Hawthorne Street
San Francisco, CA 94105
(415)947-4137 (o)
(415)947-3526 (f)
brown.catherine@epa.gov

APPENDIX C

Remediation Technology Case Studies

Name	**328 Site** **Santa Clara, CA**	**McClellan AFB**
Site History / SCM	Source area: silts and clays; 0-20 feet below ground surface (bgs). Impacted aquifers: sandy silts, silty sands, gravelly sands 20-90 feet bgs. DTW = 8 feet bgs Contaminant of Concern (COC): trichloroethene (TCE); 46 milligrams per kilogram (mg/kg) in soil, 37,000 micrograms per liter (μg/L) in groundwater Although groundwater is located approximately 8 feet bgs, the first water-bearing zone (A-level aquifer) underlies the surficial clay, and is observed within a depth interval of approximately 20 to 50 feet bgs. The second water-bearing zone (B-level aquifer) is present at depths of 50 to 90 feet bgs.	'---
Remediation using Hydraulic Barrier	A groundwater containment/treatment system was installed at the perimeter of the property in 1993 to prevent further off-site migration of impacted groundwater. The dual-phase extraction (DPE) with pneumatic fracturing (PF) system was installed at the 0.5-acre source area in 1996 to remediate shallow soils and groundwater. A DPE system was designed, installed, and operated to remove volatile organic compounds (VOCs) from silty clay soils and shallow groundwater in a former waste storage area at a large industrial manufacturing facility. Air flow through the soils was enhanced by PF between DPE extraction wells and by supplying continuous low flow/low pressure air to the fractured soils. The increased air flow caused by fracturing, within an otherwise tight clay formation, improved capture of VOCs by the soil vapor extraction (SVE) system. In addition, concurrent groundwater extraction removed highly impacted shallow groundwater. Over 40% of the VOC mass removal occurred from the vadose zone during the first month of operation. Groundwater extraction provided greater mass removal rates than SVE by the fifth month of operation. The combination of technologies has allowed SVE to be effective in an area that is not well suited for in-situ remediation.	The Air Force has determined that the selected remedies represent the maximum extent to which permanent solutions and alternative treatment technologies can be used in a practicable manner at the sites. The soil treatment component of a Composite Cap (Restricted Land Use) and Excavation/Ex-Situ Treatment/Consolidation Unit (Restricted or Unrestricted Land Use) will permanently reduce the volume, toxicity, and/or mobility of contaminants. SVE operations at sites with VOCs have achieved significant reduction in concentrations of contamination in the vadose zone. SVE systems under the VOC Record of Decision (ROD) will effectively reduce the mobility and volume of VOCs remaining on site.
Results	A significant portion of the VOC mass was removed by SVE during the first month of operation, while approximately equal VOC mass removals, by soil vapor and groundwater extraction, were achieved during continued operation. This demonstrates the efficiency of SVE compared to groundwater extraction, and also demonstrates the benefits of DPE. The system reached a steady state with respect to further remediation by the existing DPE system. VOC concentrations in groundwater and extracted vapor remained relatively constant over an extended shutdown period, and these concentrations are substantially less than they were when the DPE system began operation. In addition, VOC concentrations in the A-level aquifer have declined since the source area remediation began.	'---
Reference	U.S. EPA, 1999. *Multi-Phase Extraction: State-of-the-Practice*. EPA 542-R-99-004. June	Air Force Real Property Agency, Western Region Execution Center, 2012. *Focused Strategic Sites Record of Decision, Former McClellan Air Force Base, McClellan, CA*. February.

Name	Major Aerospace Company North Carolina	Metal/Auto Fabrication facility St. Louis, MO	Former Storage Tank Area Pleasant Hill, Iowa	TCE Site South Bend, Indiana
Site History / SCM	Contaminants of Concern (COCs): volatile organic compounds (VOCs) and 1,4-dioxane.	COCs: tetrachloroethene (PCE) Silty and clayey sands. DTW = 13-20 feet below ground surfact (bgs)	COCs: VOCs in groundwater and soil DTW = 11-15 feet bgs This former tank storage area, along with the remainder of the 5-acre facility, was surrounded in 1995 with a soil-bentonite containment wall (SBCW) that was keyed into the bedrock and/or clay till surface approximately 45 feet deep beneath grade. The presence of the SBCW contains the dense non-aqueous phase liquid (DNAPL) zone and the highest dissolved groundwater concentrations identified at the site. A gradient control treatment system (GCTS) periodically extracts groundwater from inside the SBCW to maintain an inward groundwater gradient between the outside of the wall and the inside of the wall.	TCE source area, estimated to be 350 pounds. During voluntary subsurface investigation activities at the site's former painting and degreasing operation area, soil and shallow groundwater contamination levels were discovered to be impacted with TCE. The TCE and associated degradation compounds concentrations were above industrial cleanup levels.
Remediation using IWAS	Single well in the source area to evaluate its ability to treat VOCs and 1,4-dioxane.	Well screens designed to accommodate groundwater elevation changes which may be as deep as 25 feet in dry conditions. System began operation in summer 2005.	The well was constructed to be screened from approximately 5 feet bgs to approximately 45 feet bgs, immediately above the bedrock surface. The screen is situated to cross the water table, which occurs at an approximate depth averaging from 7 to 11 feet bgs.	Based on results from previous SVE pilot testing performed in the area, ART and the consultant's design team determined that seven treatment wells would be required to achieve project objectives. The ART approach was far less intrusive than conventional AS/SVE, which would have required as many as 36 sparge wells in addition to 7 SVE wells. The ART system's actual radius of influence (ROI) exceeded the SVE pilot study's ROI by approximately 50%, including contaminant reduction.
Results	For total VOC recovery, the single Accelerated Remediation Technologies, LLC (ART) well outperformed a 10 soil vapor extraction (SVE) and 6 sparge point system that had been operating since 1994. The ART Technology proved that it effectively and cost efficiently reduced 1,4-dioxane concentrations in surrounding wells by more than 90% in a few weeks. At this site, the ART approach has been deemed to be more cost efficient than groundwater extraction and surface treatment technologies and has outperformed the existing air sparge (AS) / SVE system. The ART Technology has now been approved by the state as the primary remediation method for the site.	By August 2006, PCE concentrationin peizometers (installed near ART wells) were reduced by more than 98%. A monitoring well downgradient and ~2-3 years travel time from ART well, PCE concentrations had decreased from 6,000 ug/L (Sept. 2005) to 1,000 ug/L in August 2006. In one year, a single ART system reduced contaminant concentrations in groundwater by more than 98% in the vicinity of the ART treatment well and removed over 700 pounds of COCs from the subsurface at a superfund site in the vicinity of St. Louis, Missouri.	According to the calculations completed using pilot test data, the ART well technology was successful in removing more than 9,000 pounds of VOC mass during the pilot test duration. Overall, the VOC mass removal rate decreased throughout the period of the pilot test. The high initial VOC removal rate is likely due to the removal of readily available VOCs in the groundwater and soil vapor within the radius of influence of the test. After the initial removal, the ART system was likely only removing mass as it entered the radius of influence of the well. Alternatively, some of the reduction in mass removal rates may be due to mineralization within the ART well and/or on its components. Laboratory analytical data for groundwater indicates significant decreases in the concentrations of some parent chlorinated compounds and for other compounds such as 2-butanone and acetone. Some increases in chlorinated degradation product concentrations are also indicated. These effects are probably due to the combined effect of ART processes (stripping, sparging, vacuum extraction, etc.) and due to natural attenuation processes. It is anticipated that dissolved minerals may precipitate over time with continued addition of air to the subsurface during ART utilization. Continued precipitation will result in encrustation of the well screen, for which rejuvenation (typically consisting of acidification and surging of the well screen) needs to be periodically performed.	The system removed over 450 pounds of TCE after only 34 days. To date, over 1,200 pounds of total VOCs have been removed, including 375 pounds of PCE that had not been identified as a source area COC. Removal rate from a pump & treat system at a nearby area, which has been operating for several years, was only 13 pounds a year.
Reference	Accelerated Remediation Technologies, LLC. *VOC and 1,4-Dioxane Case History* .	Accelerated Remediation Technologies, LLC. *Superfund Site Case History.*	CH2MHILL, 2005. *ART Remediation Well Pilot Test Evaluation for the 4400 Vandalia Road Site, Pleasant Hill, Iowa.* September.	Accelerated Remediation Technologies, LLC. *TCE Case History.*

Appendix C3
Bioremediation Case Studies
Phoenix-Goodyear Airport-North Superfund Site
Goodyear, Arizona

Name	Test Area North (TAN) Idaho National Laboratory, Eastern Idaho	Silverbell Landfill WQARF Site Tucson, AZ
Site History / SCM	An injection well was operated from the 1950s to 1972 to dispose of all liquid waste streams. These included low-level radioactive wastewater, industrial wastewater (including organic liquids), and sanitary sewage, which were injected approximately 200–300 feet below ground surface (bgs). The result of this waste injection was the evolution of a nearly 2-mile-long trichloroethene (TCE) plume . Estimates of total TCE injected range from 350 to 35,000 gallons. The aquifer and most of the unsaturated zone are composed primarily of layered basalt flows, intercalated with sedimentary interbeds deposited during periods of volcanic quiescence. Groundwater flow in the aquifer is controlled by thehighly transmissive zones that occur during contact between individual basalt flows and, to a lesser extent, the fractured zones within flow interiors. DTW = 200 feet Grounwater velocity = 0.4 foot/day Porosity - 1% (unconfined aquifer) Plume divided into three sections: 1) the hot spot (residual TCE source area) 2) the medial zone 3) the distal zone. Original Record of Decision (ROD) selected pump and treat as the remedy for all three plume zones.	Tetrachloroethene (PCE) and TCE are present in groundwater at levels exceeding Aquifer Water Quality Standards (AWQS). The landfill is comprised of two waste cells, identified as the South Cell and the North Cell. The Site Conceptual Model (SCM) for the Silverbell Landfill Water Quality Assurance Revolving Fund (WQARF) site depicts the vertical downward migration of gas-phase contaminants from the landfill cells through the vadose zone to the groundwater interface, where contaminants dissolve into the groundwater. A SVE/AI was operated from 2001 through 2002 to reduce VOCs in the vadose zone. DTW = ~150 feet Groundwater velocity = 0.5 - 1 feet/day Porosity - 38% The existing Remedial Action Plan (RAP) for the site identifies a pump and treat system for remediation of the groundwater volatile organic compounds (VOCs); however, a review of historic water quality data indicated that MNA may be an appropriate alternate remedy. The preliminary evaluation of historical data indicated that natural attenuation of VOCs, including biodegradation, was occurring at the site.
Remediation using Bioremediation	Prior to bioremediation activities, redox conditions were mildly reducing near the injection well but were aerobic throughout most of the plume. Nine-month full-scale field evaluation of In-Situ Bioremediation (ISB) was performed at TAN beginning in 1999. The results showed that complete biodegradation of TCE to ethene in the residual source area was achieved as a result of electron donor injections. An monitored natural attenuation (MNA) field evaluation was conducted in conjunction with the ISB field evaluation, and the results showed that TCE attenuation was occurring. Based on the ISB and MNA field evaluation results, the regulatory agencies (i.e., the State of Idaho, U.S. Environmental Protection Agency [EPA] Region X, and Department of Energy [DOE]) accepted enhanced ISB as the selected remedy for the residual source area of the plume and MNA as the selected remedy for the distal portion of the plume A ROD amendment signed in September 2001 (DOE-ID 2001) documents regulatory approval of enhanced ISB as the final remedy for the plume hot spot and MNA as the final remedy for the distal portion of the plume.	Small volume (300 to 2,600 gallons) injections in North Cell wells using sodium benzoate and potassium benzoate (A-039A, R-081A, R-083A; July 2003 through February 2005); Large volume (5,000 to 17,000 gallons) injections in South Cell wells using sodium benzoate and potassium benzoate (R-087A, R-120A; June 2003 through July 2005); Large volume (15,000 to 17,000 gallons) injections in South Cell wells using sodium lactate (R-087A, R-120A; January 2006 through April 2006)
Results	Data collected within the residual source area during the field pilot study demonstrated that sodium lactate injections stimulated complete biological conversion of all aqueous-phase TCE to ethene within one year. The stable carbon isotope data collected also showed that the isotope ratio of the TCE changed over time, suggesting that the nature of the source term was impacted. Since then, data collected over the course of ISB operations show significant production of ethene, indicating complete dechlorination of aqueous-phase TCE. The source area bioremediation at TAN remains one of the largest-scale projects in a source area of its kind in the world; certainly in deep, fractured rock. An area approximately 60 meters (200 feet) in diameter is being treated, initially across an aquifer thickness of 60 meters (200 feet). As contaminants have been removed in the deepest part of the contaminated aquifer, which presumably was limited to aqueous- (and possibly some sorbed-) phase contamination, the focus is now on the upper 30 meters (100 feet) of the aquifer. Both field and laboratory data have demonstrated that bioremediation through injection of high concentration electron donor solutions has enhanced depletion of the residual source by enhancing mass transfer into the aqueous phase. The biodegradation kinetics have largely remained faster than the mass transfer kinetics, leading to an optimization strategy largely devoted to accelerating mass transfer rates even further. This requires continued injections of high concentration electron donors throughout the area impacted by residual source material. As the volume of this area is large and the transmissivity of the aquifer is very high, injection volumes are larger than at many other chlorinated solvent sites.	Based on Pilot Study, sodium benzoate is capable of supporting reductive dechlorination of PCE under following conditions: Minimum injection volume of 15,000 gallons per well; Monthly injections; Injection concentration ~4,000 milligrams per liter (mg/L), may be higher (~6,000 mg/L) at the beginning of injection in a new well to establish microbial population. With sodium benzoate, a consistent reduction of daughter products , including TCE, dichloroethene (DCE), and vinyl chloride (VC), to levels less than AWQSs was not exhibited during pilot studies. Daughter product concentrations may persist and accumulate to high concentrations when sodium benzoate is applied in areas with higher PCE concentrations. Sodium lactate is capable of supporting complete reductive dechlorination of chlorinated solvents (PCE and daughter products) under following conditions: Minimum injection volume of 15,000 gallons per well; Monthly injections; 0.5% injection concentration or less, higher at beginning of injection in a new well (1.0%). Preliminary data indicates that sodium lactate is more efficient than sodium benzoate at the consistent reduction of sulfate and PCE daughter products, including DCE. Based on these results and application difficulties associated with sodium benzoate, sodium lactate was recommended in an enhanced bioremediation strategy, if enhanced bioremediation is used as part of the ADEQ-approved remedial strategy for the Silverbell Landfill WQARF site.
Reference	Interstate Technology and Regulatory Council (ITRC), 2007. I*n Situ Bioremediation of Chlorinated Ethene DNAPL Source Zones: Case Studies. Prepared by the ITRC Bioremediation of DNAPLs Team* . April.	City of Tucson Environmental Services, Silverbell Landfill WQARF Site, Groundwater Remediation Project, 2006. *Enhanced Bioremediation Pilot Study - South Cell, Summary Report, June 2003 through April 2006* . Prepared by Malcolm Pirnie, Inc., Tucson, AZ. May.

Name	**Patrick Air Force Base Florida**	**Naval Air Engineering Station Lakehurst, NJ**	**Naval Air Station Jacksonville, FL**	**Hunters Point San Francisco County, CA**
Site History / SCM	Contaminants of Concern (COCs): trichloroethene (TCE) and daughter products; TCE as high as 150,000 micrograms per liter (µg/L). Industrial area, Resource Conservation and Recovery Act (RCRA). Full-scale. Soil and groundwater impacted.	The principal contaminants found in the groundwater at Areas I and J include tetrachloroethene (PCE), TCE, 1,1,1-trichloroethane (1,1,1-TCA), and degradation products such as cis-dichloroethene (cis-DCE) and vinyl chloride (VC). The contamination extends vertically 70 feet below the groundwater table. The largest amount of contamination is located in the zone from 45 to 60 feet below the groundwater table.	COCs: TCE, 1,1,1-TCA in groundwater. Geologic borings indicate that the unsaturated zone at the site appears to be fairly uniform fine to medium grained sand and sandy fill. A thin layer of clayey sand and/or silty sand is located at and just below the water table between 6 and 12 feet bgs, underlain by a fine to medium silty sand encountered from 10 to 17 feet bgs. At most locations within H1K, a larger amount of silt and clay was encountered between 20 and 24 feet bgs. Below 24 feet bgs, stiff, dense, very low permeability clay was encountered to a depth of 54 feet bgs. The surficial aquifer at the site is located approximately 7 to 24 feet bgs, and tends to flow to the southeast.	ZVI at Site RU-C4 in the eastern portion of the site. Two aquifers and one water-bearing zone have been identified at Hunters Point: the A-aquifer, the B-aquifer, and the bedrock water-bearing zone. Groundwater flow patterns are complex due to heterogeneous hydraulic properties of the fill materials and weathered bedrock, tidal influences, effects of storm drains and sanitary sewers, and variations in topography and drainage. DTW = ~6.8 feet bgs (6.2 feet bgs post-injection). Hydraulic conductivity in A-aquifer: 26.6 - 43 feet/day; in bedrock water-bearing zone 0.052 to 40 feet/day. GW gradient generally flat. COCs: chlorinated solvents, primarily TCE in shallow groundwater.
Remediation using nZVI	Volume of treated media: 600,000 cubic feet (22,222 cubic yards) Emulsified ZVI (EZVI), high pressure pneumatic injection	Bimetallic Nanoscale Particle (BNP) iron was injected using direct-push technology (i.e., Geoprobe) at 15 locations. The injection intervals for each point included 66 to 70, 62 to 66, 58 to 62, 54 to 58, and 50 to 54 feet below ground surface (bgs).	The horizontal extent of contamination is approximately 1,450 square feet with a thickness of 18 feet (saturated zone), resulting in a total volume of 967 cubic yards of soil. The estimated mass ranges between 42 and 125 pounds with the statistical average mass centered at 61 pounds. NZVI was emplaced using two mechanisms: (1) strategic direct-injection into known "hot spots" using direct-push technology (DPT), and (2) a "closed-loop" recirculation process. Direct injection of the nanoscale iron using DPT was employed first at 10 "hot spot" locations. A recirculation system was used to distribute the nZVI in the rest of the suspected source zone.	First Study - Ferox microscale ZVI; 16,000 pounds ZVI powder. Treatment zone of 900 square feet by 22 feet thick. Estimated radius of influence (ROI) 15 feet. Injection process integrated pneumatic fracturing and Ferox delivery into one process. Nitrogen gas was used as both fracturing and injection fluid. 4 boreholes - 3-foot intervals, starting at 30 feet bgs upward to at least 10 feet bgs. Expected to cover the zone from 32 feet bgs to about 7 feet bgs (the approximate water table). Second Study - 72,650 pounds ZVI powder, same delivery methodology. 13 boreholes at 3- to 4-foot intervals, starting at deepest interval and proceeding upward (up to 60 feet bgs).
Results	Highest remaining TCE post treatment : 3,580 µg/L.	A substantial reduction in the dissolved-phase concentration of the target chlorinated volatile organic compounds (CVOCs), (PCE, TCE, DCE, and VC), was observed following nanoscale zero valend iron (nZVI) injection. However, from the monitoring data, it is unclear what caused this reduction in CVOC concentrations. Indicators of strongly reducing conditions (oxidation reduction potential [ORP] of −400 mV or lower) suitable for abiotic reduction (beta-elimination) or even mildly reducing conditions anaerobic enough to favor biodegradation or hydrogenolysis were absent in the monitoring data. There was no substantial pH increase observed in the monitoring wells. In fact, in many cases, ORP increased and pH decreased after nZVI injection. One possible explanation is that the nZVI was passivated before injection, when it was slurried with a large volume of highly aerated hydrant water or water pumped out of a recovery well. The decline in CVOC levels observed in the monitoring wells could be a result of dilution due to the injection of 18,000 gallons of water (iron slurry) into the treatment zone. The observed increase in CVOC levels in 50% of the monitoring wells may indicate that injected water displaced native water containing dissolved CVOCs in the source zone.	nZVI injection caused a substantial reduction in TCE levels in several source zone wells. ORP reduction was experienced in most monitoring wells in the source zone, indicating that the direct-push and recirculation methods of injection worked relatively well. Some migration of nZVI outside the treatment zone may have occurred through preferential pathways. The substantial increases in cis-1,2-DCE and 1,1-DCA indicate that microbially driven anaerobic reductive dechlorination and hydrogenolysis may have played a primary role in the CVOC treatment. The nZVI injected did not create the strongly reducing conditions (ORP of −400 mV or lower) necessary to generate substantial abiotic degradation of TCE. One possibility is that the nZVI was passivated before injection when it was mixed with oxygenated water (groundwater extracted from one of the wells was used to prepare the iron slurry). nZVI has a very small particle size, is highly reactive, and can react rapidly with oxygenated species (e.g., dissolved oxygen, nitrate, etc.) in most water supplies. Another possibility is that insufficient iron may have been injected. Iron mass needs to be determined based on iron-to-groundwater (or iron-to-soil) ratio, rather than iron-to-contaminant ratio (an ORP of < −400 mV must be achieved in the target treatment volume). To some extent, nZVI migration outside the treatment zone also reduced the mass of iron in the targeted zone.	First Study - Dissolved TCE levels declined sharply in all monitoring wells in the treatment zone, without any significant formation of cis-1,2-DCE and VC. Sharp declines in ORP and noticeable increases in pH support the contention that the strongly reducing conditions suitable for abiotic reduction of CVOCs were created. Injecting a ZVI mass in excess of contaminant stoichiometry was necessary to bring about significant abiotic reduction of CVOCs. Pneumatic fracturing combined with liquid atomization injection of the ZVI slurry was successful in distributing ZVI through most of the target treatment zone. Slow nitrogen distribution through the formation at Hunters Point led the vendor to use pulses of nitrogen rather than a steady flow to distribute the ZVI. Pulsing helped to prevent excessive pressure buildup and surface heave. Injecting at shallow depths may lead to nitrogen and slurry seeping up to the ground surface. Switching to direct hydraulic pumping may reduce the potential for seeping to the ground surface and the risk of contaminant vapors escaping from the subsurface. Second Study - TCE was reduced rapidly in the treatment zone wells, as was DCE. However, DCE is already showing signs of rebound in several wells and TCE itself appeared to be rebounding in one well. This indicates that dissolved-phase TCE was treated in the short-term, but sorbed TCE may gradually show up as dissolved-phase in the monitoring wells. These results indicated that TCE and DCE initially were reduced by strong abiotic reactions in some portions of the target treatment zone. However, in some portions of the treatment zone, TCE and DCE are degrading mostly byslower biodegradation or hydrogenolysis reactions.
Reference	United Stated Environmental Protection Agency, 2008. Office of Solid Waste and Emergency Reponse. *Nanotechnology for Site Remediation Fact Sheet.* EPA/542/F-08/009.	Gavaskar, Arun, et al., 2005. *Cost and Performance Report, Nanoscale Zero-Valent Iron Technologies for Source Remediation. Naval Facilities Engineering Command, Contract Report CR-05-007-ENV* . September.	Gavaskar, Arun, et al., 2005. *Cost and Performance Report, Nanoscale Zero-Valent Iron Technologies for Source Remediation. Naval Facilities Engineering Command, Contract Report CR-05-007-ENV* . September.	Gavaskar, Arun, et al., 2005. *Cost and Performance Report, Nanoscale Zero-Valent Iron Technologies for Source Remediation. Naval Facilities Engineering Command, Contract Report CR-05-007-ENV* . September.

Name	**MGP** **Portland, OR**	**Sierra Army Depot PRB Project** **Honey Lake Valley of Lassen County, NE California**	**Continental Grain Elevator, French Camp** **San Joaquin County**
Site History / SCM	Industrial operations at the facility included the use of trichloroethene (TCE) from approximately 1980 to 1989. TCE and/or TCE-containing wastewater were released to the subsurface, roughly between 1980 and 1984, but the exact date and volumes are unknown. Direct-push investigation in the source area showed that dissolved-phase concentrations of TCE and cis-1,2-dichloroethene (cis-DCE) ranged as high as 592,000 and 90,000 micrograms per liter (µg/L), respectively, at depths ranging from approximately 50 to 110 feet below ground surface (bgs). The soil in the source area consists of fill (from 0 to 25 feet bgs), underlain by silt (about 25 to 50 feet bgs), silty sand (to about 170 feet bgs), and gravels and cobbles (to about 200 feet bgs), underlain by basalt characteristic of the Columbia River Basalt deposits. GW Velocity = 0.1-0.2 feet/day	The total area of the main depot is over 30,000 acres. The PRB project was located in the Building 210 Area near the southeast corner of SIAD. From 1942 until 1949 this area served as a vehicle maintenance facility. Additional activities included sand blasting, spray painting, steam cleaning, powder packaging, and tank engine fogging. Wastes generated at this site included degreasing solvents, oils, and sludge. Buildings adjacent to Building 210 were also used for vehicle maintenance from the 1940s until 1973. TCE was first detected in the groundwater in the Building 210 area in 1995. Site investigations found that the contamination plume had migrated off post to the south and is now greater than 3,500 feet long. The maximum TCE concentration in the core of the plume is approximately 2,500 parts per billion (ppb). At depths below 115 feet below ground surface (bgs), a layer of impermeable clay/silt is encountered which acts as an aquitard to the contaminated groundwater layer. Water flow in the area is to the southeast at 0.2 to 0.5 feet/day. DTW = 80-115 feet bgs	Contaminants of Concern (COCs): Carbon Tetrachloride and chloroform. Carbon tetrachloride was found in groundwater in a property transfer assessment in 1999. In May 2005, ZVI was injected into the source area using hydraulic fracturing. In May 2008, one set of recirculation wells was started, in which groundwater is extracted downgradient of the iron zone and recirculated back through the iron zone. DTW = 25 feet
Remediation using ZVI	A comparative bench test demonstrated that the combination of EHC® and KB-1® was more effective and appropriate for meeting the project objectives than two other commercially available electron donors. An extensive field pilot test confirmed the effectiveness of the sequential in-situ installation in the TCE dense non-aqueous phase liquid (DNAPL) source zone. During the field pilot, TCE concentrations were reduced from concentrations indicative of DNAPL (approximately 11,000 to 100,000 µg/L), to concentrations approaching or below the Maximum Contaminant Level (MCL) (1 to 10 µg/L). These results indicated that In-Situ Chemical Reduction (ISCR)-enhanced bioremediation of TCE DNAPL to MCL levels is a rapid, effective, and practical alternative. Full-scale implementation consisted of an approximately 150-foot-long permeable reactive barrier (PRB) containing EHC and KB-1, installed at depths ranging from approximately 40 to 112 feet bgs using direct-push technology. Supplemental injections were completed upgradient of the PRB to treat additional source areas. EHC was injected first, followed later (usually 7 to 14 days) by KB-1 injections. The EHC was injected at 4-foot vertical intervals, with 2-foot offsets between injection rows to enhance the vertical coverage. Injections commenced in January 2009 and were completed in June 2009.	In July 2002, ARS Technologies installed an iron PRB at the site using their patented Ferox technology. In this technology, an injector assembly is inserted into a predrilled well and zero valent iron (ZVI) powder slurry is injected into the ground using nitrogen or compressed air as a carrier. The PRB was installed using a grid of 9 injection wells spaced 40 feet apart. Approximately 42,000 pounds of ZVI were injected into the subsurface at the site between a depth of 95-115 feet bgs.	In May 2005, Continental Grain injected ZVI into subsurface hydrofractures. Carbon tetrachloride is removed as groundwater passes over the iron. In June 2008, Continental Grain installed an extraction and reinjection system to facilitate contact of groundwater with the iron.
Results	TCE concentrations were reduced to below the injection threshold in most of the PMWs within six months of commencing injections, and the Remedial Action Objective (RAO) was achieved in all of the wells within five months of injection completion. The average preinjection concentration of TCE in the Group 1 PMWs initially above the injection threshold was reduced from 82,933 µg/L to 1,238 µg/L in December 2009. The average preinjection concentration of TCE in Group 2 PMWs initially above the injection threshold was reduced from 21,733 µg/L to 2,638 µg/L. Five months following completion of a PRB and supplemental treatment zones composed of EHC and KB-1, the RAO was met in all 23 of the monitoring points. Furthermore, the MCL for TCE (5 µg/L) was achieved in 9 of the 23 mointoring points. The TCE percent mass reduction ranged as high as 99.1% in the injection zone, and 98.6% downgradient of the injection zone. Other data confirmed that the injected amendments are advecting downgradient and treating potential DNAPL mass located in inaccessible areas under the adjacent building. Removal of TCE and its degradation products is occurring by both abiotic and microbially mediated pathways. A weight-of-evidence approach to data assessment confirms that ISCR is a potentially effective remedial technique for chlorinated-solvent DNAPL source zones in relatively deep, heterogeneous aquifers.	Based on the above monitoring well results, there appears to be little reduction in TCE concentration across the PRB. The northward extent of the contaminant plume suggests that groundwater flow had reversed in the past due to groundwater extraction and treatment activities in the area. Such groundwater flow reversal would certainly have impacted PRB performance. However, an examination of the potentiometric published in 2003 through 2005 shows a consistent groundwater flow gradient. The geology and depth of the site presented several challenges to ARS. The drilling method had to be modified due to running sand and the depth at the site. The 42,000 pounds of iron is the equivalent of a 1-inch thick iron barrier behind the 4,000 square foot facial area of the PRB. The installed thickness does not appear adequate for achieving treatment to desired MCL levels. Using the EPA Scoping Calculations equation modified for TCE and a groundwater flow rate of 0.5 feet/day, a minimum PRB design thickness of 2.4 inches of iron would be needed to treat an initial TCE concentration of 2,500 ppb to the clean-up goal of 5 ppb.	In 2006, Continental Grain is concluded a pilot study evaluating ZVI injections to treat carbon tetrachloride and chloroform in-situ. One year after the injections were made, clear declines in carbon tetrachloride are apparent in two wells nearest the injection zone.
Reference	Davis, James G.D., et al., 2010. *Successful ISCR-Enhanced Bioremediation of a TCE DNAPL Source Utilizing ECH® and KB-1 ®*. REMEDIATION, Summer 2010.	Office of Pollution Prevention and Technology Development, California Department of Toxic Substances Control, 2008. *An Assessment of Zero Valence Iron, Permeable Reactive Barrier Projects in California* . April.	Huff & Huff, Inc. and Advanced GeoEnvironmental, Inc., 2009. *Groundwater Recirculation System Pilot Study Evaluation Report for French Camp Grain Elevator, French Camp, CA* . August.

Name	**UGS Corporation Facility** **La Mirada, CA**	**Old Hammer Field (OHF)** **Fresno, CA**	**Tucson International Airport Superfund Site** **Tucson, AZ**
Site History / SCM	Contaminants of Concern (COCs): tetrachloroethene (PCE), trichloroethene (TCE), and 1,1-dichloroethene (1,1-DCE). Silty sand/sandy silt alluvial aquifer. The aquifer thickness is approximately 25 feet (depths of 80–105 feet below ground surface [bgs]). GW Velocity = 0.17 feet/day	Numerous military and civilian entities have performed industrial activities at OHF since it was developed in the 1940s. Based on the types and locations of historical activities, OHF has been divided into several distinct environmental investigation areas. Area 1, which is also referred to as the Redevelopment Area, has been the primary focus of investigations and remedial activities at OHF. Area 1 has historically had the most intensive industrial activity at OHF, both during and after World War II. The most notable activities in this area with respect to environmental concerns have been related to aircraft maintenance and fueling operations. DTW = 103 - 125 feet bgs In 2005, a soil vapor extraction (SVE) system was designed and implemented in the Area 1 source area (also referred to as the Hangar P3/282 Source Area) to address volatile organic compound (VOC) concentrations in soil and soil vapor. Wessl screened from 15-45 feet bgs and 50 to 90 feet bgs.	The principal contaminants of concern are TCE, 1,1-DCE, and chromium. Three aquifer zones - shallow groundwater zone, and upper and lower zones of regional aquifer. DTW = 90-190 feet bgs The groundwater remediation system is made up of a regional aquifer reclamation system and a shallow groundwater zone reclamation system. Two basic methods are employed for remediation of VOCs in soils; conventional SVE and dual-phase extraction (DPE). SVE and DPE have been used for remediation of soils with VOC contamination at APF 44 since 1995. Neither SVE nor groundwater pump-and-treat methods were capable of removing TCE non-aqueous phase liquid (NAPL) concentrated in fine-grained, low permeability soils.
Remediation using ISCO	The areal extent of the entire plume measured approximately 55,000 square feet, although this pilot test was performed to determine the effects of In-Situ Chemical Oxidation (ISCO) treatment on a much smaller portion of the plume, approximated at 1,375 square feet. The highest pretreatment level of TCE was 450 micrograms per liter (µg/L), and of 1,1-DCE was 700 µg/L. The pilot test consisted of six injections each of 1,500 gallons of potassium permanganate ($KMnO_4$) solution (up to 5% by weight) into a single groundwater injection well (screened interval of 80–100 feet bgs) (total injection quantity of 9,000 gallons). The radius of influence was determined to be approximately 35 feet. The actual treatment radius was extended another 15 feet by inducing a hydraulic gradient via the pumping of groundwater from a downgradient well.	Potassium permanganate ($KMnO_4$) into the saturated zone to oxidize dissolved-phase VOCs in the Area 1 source area. Phased approach, which includes installation of chemical injection wells upgradient and performance monitoring wells downgradient of the source area, periodic injection of 2% $KMnO_4$ solution into injection wells over 3 years, and monitoring of downgradient wells to evaluate the effectiveness of chemical injection and ensure that Well 70 is protected.	Bench-scale studies were conducted by the University of Arizona using AFP 44 groundwater and core samples from the aquifer, which proved that potassium permanganate solution could effectively destroy large concentrations of TCE under site-specific conditions. Pilot testing of in-situ oxidation using potassium permanganate was first conducted at AFP 44 in August 2000. Expanded pilot test - the vadose zone was treated with 6,165 pounds of potassium permanganate injected in 258,000 gallons of water. A total of 10,090 pounds of potassium permanganate was injected in 352,000 gallons of water into the eight regional aquifer wells between June and December 2003. The total quantity of potassium permanganate applied to the site in the vadose zone and regional aquifer was 16,255 pounds. Additional injection of potassium permanganate was conducted in the Site 2 area between July and December 2005. The additional injection was done to address rebound of TCE concentrations in some wells.
Results	Significant reductions of TCE and 1,1-DCE concentrations, from 86% to 100%, were detected shortly following the injections. The TCE concentrations in the three closest monitoring wells, within 35 feet of the injection well, were all reduced to nondetectable (ND) levels (<1.0 µg/L) during the first 70 days of the pilot test. This included a maximum reduction of TCE from 280 µg/L to ND (<1 µg/L). Over the next 90 days, three additional wells (45 to 50 feet away) also began to show significant TCE reductions, with a maximum decrease in TCE from 450 to 65 µg/L. Effective treatment of 1,1-DCE was also observed in five wells, declining from 270 µg/L to ND (<1.0 µg/L) in one well and from 700 to 19 µg/L in another well. No significant rebound of TCE or 1,1-DCE levels has been monitored for 12 months following the pilot test.	The ISCO remedial action appears to have reduced TCE concentrations within the source area and adjacent downgradient areas. Key monitoring wells either no longer contain detectable TCE concentrations or have shown significant reductions from the maximum concentrations detected historically. The original objective of the ISCO remedial action was to reduce TCE concentrations in the source area, more specifically, the area estimated by the original 1,000 µg/L isoconcentration contour line. Based upon the data that have been collected over the past 2 years (~2007-2008), this objective has been met.	Additional injection of potassium permanganate was conducted in Site 3 to address rebound of TCE concentrations in some of the Site 3 wells. The rebound was discovered during the February-March sampling event, when it was noted that potassium permanganate was no longer present in most of the wells sampled. It was not clear whether the permanganate was consumed or had been flushed away. Although injection volumes and concentrations were comparable, the permanganate proved to be far less persistent in Site 3 than in Site 2. The $KMnO_4$ solution was injected in the vadose zone above the fine-grained unit at one site, and was injected into a coarse grained unit immediately below the fine-grained unit at the second site. Sampling of wells impacted by $KMnO_4$ injection revealed significantly reduced TCE concentrations, followed by periods of rebound. However, three months after injection, TCE concentrations in most wells were still less than 50% of pre-test concentrations. Full rebound of TCE concentrations would be expected within two to three weeks if no TCE NAPL had been oxidized. In addition, no evidence of remobilization of chromium was found.
Reference	Interstate Technology and Regulatory Council (ITRC), 2005. *Technical and Regulatory Guidance for In Situ Chemical Oxidation of Contaminated Soil and Groundwater, Second Edition*. Prepared by the ITRC In Situ Chemical Oxidation Team. January.	ERM, 2009. *2008 Annual Progress Report, Old Hammer Field*. Fresno, CA. February.	Raytheon Company and Errol Montgomery & Associates, 2006. *Tucson International Airport Area Superfund Site, Summary of Reclamation Well Field and Soil Remediation Operations, July 2005 through June 2006*. U.S. Air Force Plant 44. September.

Name	Former Williams Air Force Base Mesa, AZ	Building 181 TCE Source Area Air Force Plant 4, Fort Worth, TX	Paducah Gaseous Diffusion Plant Pilot Study Paducah, KY
Site History / SCM	The Conceptual Site Model (CSM) addresses an area that is approximately 2,400 feet by 1,600 feet, extending vertically to a depth of approximately 240 feet below ground surface (bgs). These layers are, from deepest to shallowest, crystalline rocks, extrusive rocks, Red Unit, Lower Unit, Middle Unit, and the Upper Unit. The crystalline and extrusive rocks underlie the basin and outcrop at the surface in the surrounding mountains. These rocks and the surrounding mountains form the vertical and lateral hydrogeologic boundaries of the Higley Basin. The nearby mountains are the source of most of the sedimentary deposits that fill the basin. This ST012 CSM Report (Version 3.0) addresses the former Liquid Fuel Storage Area (ST012), located at the former Williams Air Force Base (WAFB) in Mesa, Arizona. WAFB is on the National Priorities List (NPL). Soil and groundwater were impacted primarily by releases of Jet Fuel – Grade 4 (JP-4) and aviation gasoline (AVGAS) over the fifty years of ST012 operation. Shallow vadose zone completed using soil vapor extraction (SVE) in 1990s. Deep vadose zone soil treatment is ongoing using SVE. The groundwater contamination remedy specified in the 1992 Record of Decision (ROD) involved groundwater extraction, treatment, and reinjection using two horizontal extraction wells. That remedy, constructed and tested in the 1990s, was ineffective due to low groundwater extraction rates and the rapidly rising water table at ST012. Currently, the Air Force and regulatory agencies have agreed to implement a pilot test of a proposed alternative extraction and treatment technology, Thermal Enhanced Extraction (TEE), to assess its practicability as a component of a revised remedy involving active thermal treatment of the fuel source area, followed by MNA of the groundwater plume to attain groundwater cleanup levels for the contaminants of concern (COCs) at a downgradient Reference Boundary within 50 to 100 years.	The TCE source material is believed to be degreaser tanks in Building 181 that have since been removed. Building 181, the Chemical Process Facility, is part of the Assembly Building/Parts Plant. In May 1991, a TCE vapor degreaser tank in Building 181 was discovered to be leaking. A documented TCE release from tank T-534 was estimated at 20,000 gallons . On 15 June 1991, tanks T-544 and T-534 were removed from service. On the basis of several subsequent investigations, it was found that releases of TCE had migrated through cracks in the concrete building floor, resulting in contamination in the unsaturated zone, including Terrace Alluvium and overlying fill soil under Building 181. The hydrogeologic interval targeted by the Electrical Resistance Heating (ERH) application includes the Terrace Alluvium and weathered bedrock to a depth of approximately 35 feet bgs. DTW = 25 feet bgs GW Velocity = 13-132 feet/day Initial remediation approach - SVE and pump and treat (P&T)	TCE is found throughout the upper formations and exists at non-aqueous phase liquid (NAPL) concentrations on top of the clay-rich McNairy formation. The unsaturated and saturated zones of the Upper Continental Recharge System (UCRS) extend from grade to approximately 55 feet bgs, and the saturated Regional Gravel Aquifer (RGA) extends from the bottom of the UCRS to the top of the McNairy formation, at about 90 feet bgs.
Remediation using ERH	The Air Force commenced a pilot project utilizing TEE to address the contamination in 2009. TEE utilizes steam to mobilize petroleum to remove it from soils and groundwater. A report cataloguing the performance of the pilot project was presented for evaluation in 2010. Discussions on capture effectiveness and possible expansion of the technology have been ongoing.	ERH was selected on recommendations in a remedial design report and a successful pilot test. ERH was designed to work in conjunction with the existing SVE system.	The objective of the pilot test was to demonstrate the feasibility of ERH to simultaneously reduce TCE concentrations in the tighter and partially unsaturated UCRS and the more permeable saturated RGA, and remove NAPL from the top of the McNairy formation. To accomplish these goals, heating was extended to approximately 100 feet bgs, making the pilot test the deepest application of the ERH technology to date. Electrodes were constructed to a final depth of approximately 97 feet bgs, and each electrode consisted of six depth-discrete, electrically conductive intervals covering the UCRS, the RGA, and the upper layer of the McNairy Formation. Captured TCE vapors were treated using 13,000-pound, vapor-phase, granular activated carbon (GAC) vessels and treated air was released to the atmosphere. Recovered steam was condensed and the condensate treated with liquid-phase GAC before being recycled within the aboveground system as makeup water for the ERH processes.
Results	As of February 2010, the pilot test have been concluded, after having successfully removed 118,331 pounds of petroleum hydrocarbons and 3,652 pounds of benzene from the subsurface. The pilot was operated on a schedule due to funding constraints. Free product was still being recovered as operations ceased. The intent of the pilot was to demonstrate the removal effectiveness. The Air Force is currently preparing a final report before recommending the next course of action. The Air Force is summarizing their findings and will recommend optimization of the design for a full scale remedy.	A calculated total of 1,413 pounds of TCE were removed from the subsurface in Building 181 via the steam extraction system (only about half of one pound was removed via condensate). TCE in soil vapor was reduced by 93%, TCE in soil was reduced by 90%. All post-ERH soil results were below the Remedial Action Objective (RAO) of 11.5 milligrams per kilogram (mg/kg) TCE. Groundwater results mean TCE concentration was reduced by 87%. A 353% increase in average chloride concentrations was noted and may indicate enhanced biodegradation of TCE. The ERH application proved successful in heating the subsurface and removing TCE contaminants from the soil and groundwater at the site. The RAOs for soil and groundwater were met, and soil vapor TCE concentrations were reduced significantly. Although the desired temperature was observed through most of the array, it did not appear to be adequate in the vicinity of MW-10.	Once design temperatures were achieved in the subsurface, approximately 350–400 pounds of TCE were recovered each day of operations, and more than 30,000 pounds of TCE were removed from the subsurface over the course of the 175- day pilot study. Confirmatory sampling showed that concentrations of TCE inside the treatment area were reduced by an average of 98% in soil and 99% in groundwater. At the conclusion of heating, groundwater samples from all 11 monitoring wells contained TCE at concentrations below 11 mg/L. Heating was started in February 2003 and continued until fall 2003. Based on the success of the pilot project, the U.S. DOE is planning to expand ERH to full scale in three areas at the Paducah Gaseous Diffusion Plant.
Reference	Air Force Center for Engineering and the Environment, 2007. *Final ST012 Phase 1 Thermal Enhanced Extraction (TEE) Pilot Test Work Plan* . Former Williams Air Force Base, Mesa, AZ. Prepared by BEM Systems, Phoenix, AZ. November.	Air Force Center for Engineering and the Environment, 2004. *Final Enlarged Electrical Resistive Heating Application Construction and Performance Report, Air Force Plant 4, Fort Worth, TX* . Prepared by URS Corporation, Austin, TX. June.	Beyke, Gregory and Fleming, David, 2005. *In Situ Thermal Remediation of DNAPL and LNAPL Using Electrical Resistance Heating* . REMEDIATION, Summer 2005.

APPENDIX D

Cost Estimates and Supporting Documentation

D1 – General Costs

AMERICAN
1-877-933-6336
AMERICANFENCE.COM

American Fence Company, Inc.
2502 N. 27th Ave. Phoenix, AZ. 85009
Phone 602-272-2333 Fax 602-278-6068

QUOTE SHEET

Time: ________ Date: 12/23/2009

Name of Company: ERM

Office: ________ Mobile: ________ Fax: jason.hilker@erm.com

Person Calling for Quote: Jason

Job Location: 102 South Litchfield Rd. Goodyear, Az. 85338

Scope of work Temp. Fence.

Footage: 392 Feet Est. Duration of Job: 1 Mos. # of panels: 28ea.

Fence to be installed on: **T-Stands**

Barbed Wire? **No**

Gates: Walk ________ Drive included PO# ________ RO# ________

Is Job Accessible? **Yes** Is Job Hand Carry? **No**

C.O.D.?

Note: Entire job will be installed with paneled fencing that can be pounded in the dirt. If you are requesting barbed wire, it will be included at no additional charge (based upon availability).

This quote is valid for 30 days subject to terms and conditions

Price for Installation, Removal, & Term of Rental	$ 577.10
Fuel Surcharge	$ 0
Tax	$ 47.90
Total	$ 625.00

Salesperson Name: Thomas J. Allen Phone #: 602.3303271 cell
602.734.2812 office

Locations:

FULL SERVICE LOCATIONS:

PHOENIX, AZ	TUCSON, AZ	SALT LAKE CITY, UT
MESA, AZ	SAN MARCOS, CA	FARMINGTON, NM
SHOW LOW, AZ	WICHITA, KS	ALBUQUERQUE, NM
PRESCOTT, AZ	KANSIS CITY, MO	LAS VEGAS, NV

RENT-A-FENCE (ONLY) LOCATIONS:

SANTEE, CA	DENVER, CO
LOS ANGELES, CA	
PERRIS, CA	
HOUSTON, TX	

Yellow Jacket Drilling Services, LLC
P. O. Box 801
Gilbert, Arizona 85299

Telephone: (602) 453-3252
Fax: (602) 453-3258

Preliminary Project Estimate

Date: 24-Dec-09
Quote No : 09-1259AZ
Page: 1 of 2

For : ERM
Type of Project : material Unloadinç
Project Name : PGA
Location : Goodyear, AZ

Total Feet of Drilling Requirec NA

Quantity	Description	Unit Cost		Total
TASK 1	**Unload Material at Staging Area**			
1	Mobilization & Demobilization	$200.00	ea.	$200.00
0.5	Forklift Rental	$250.00	day	$125.00
4	Laborer to Operate Forklift (4 Hour Minimum)	$60.00	ft.	$240.00
		Total Estimated Cost →		**$565.00**

Average Cost Per Foot **#VALUE!**

Yellow Jacket Drilling (YJD) Proposal Assumptions & Conditions:

1.) All drilling locations are to be clear of any and all overhead & subsurface utilities (i.e. Bluestake, One Call, Underground Alert).
2.) Profiling and disposal of all soil cuttings and fluids generated will be the responsibility of the 'Client.'
3.) Any required traffic control and site security during all working & non-working hours will be provided by the 'Client.'
4.) Project is not subject to surcharges for Union/Davis Bacon/Prevailing labor rates.
5.) If the project encounters difficulties beyond our control or if the scope of work is altered, YJD reserves the right to renegotiate the price.
6.) This proposal is valid for sixty (60) days from the above date.

All services rendered will be billed promptly upon completion of the work. Terms are net thirty (30) days unless otherwise agreed in writing in advance.

Yellow Jacket Drilling would like to thank you for this opportunity to provide the enclosed cost estimate. If you have any questions, or if we may be of any further assistance, please do not hesitate to contact us at 602-453-3252. We look forward to hearing from you soon.

Sincerely,
Yellow Jacket Drilling

Paul McAlpine
Project Manager

Acceptance of all outlined pricing, terms and conditions:

Company Name:____

Authorized Representative (Name & Title):____

Signature:____

YELLOW JACKET
DRILLING SERVICES

The Southwest's Premier Provider of Innovative Drilling and Well Services

Ms. Suzanne Bell
Haley & Aldrich
600 S. Meyer Avenue
Tucson, AZ 85701-2554

Date: 8/30/12
Bid # (A)JT12-1720

Subject:

Drilling Services -- PGA-North Injection & Monitor Well Abandonments, Goodyear, AZ

Scope of Work:

Utilizing a (Well Abandonment) crew:
Injection Wells
Abandon (45) 4" SCH. 40 PVC wells to an average depth of 150' (pressure-grout with high-solids bentonite grout, and remove surface completion).
Monitoring Wells
Abandon (9) 4" SCH. 40 PVC wells to an average depth of 135' (pressure-grout with high-solids bentonite grout, and remove surface completion).
*Note: Well abandonments will be as outlined in 'Client' provided RFP dated 8/28/12.

Item	Quantity	Unit	Cost		Price	
Project Pricing Summary						
Well Abandonment Crew; Mob/Demob	1	LS	$	1,125.00	$	1,125.00
Injection Well Abandonment (4" x 150')	45	EA	$	1,200.00	$	54,000.00
Monitoring Well Abandonment (4" x 135')	9	EA	$	1,110.00	$	9,990.00
IDW Containment & Site Security	1	EA	$	960.00	$	960.00
Estimated Project Total					**$**	**66,075.00**

Item	Quantity	Unit	Cost		Price	
Pricing Breakdown - Injection Well Abandonment (4" x 150' Average)						
Permit; ADWR Well Abandonment Card	0	EA	$	250.00	$	-
Well Abandonment; Pressure-Grout 4" Well	150	FT	$	6.00	$	900.00
Pumping Equipment; Submersible - Pull & Stack	0	EA	$	420.00	$	-
Surface Completion; 8" Field Grade - Removal	1	EA	$	300.00	$	300.00
Surface Completion; 12" Flush Grade - Removal	0	EA	$	400.00	$	-
Surface Completion; Patch with Redi Mix Concrete (Up to 3' x 3')	0	EA	$	50.00	$	-
Abandonment Crew Standby ('Client' Directed Work Stoppage..)	0	HR	$	225.00	$	-
Subtotal					**$**	**1,200.00**

Item	Quantity	Unit	Cost	Price
Pricing Breakdown - Monitoring Well Abandonment (4" x 135' Average)				
Permit; ADWR Well Abandonment Card	0	EA	$ 250.00	$ -
Well Abandonment; Pressure-Grout 4" Well	135	FT	$ 6.00	$ 810.00
Pumping Equipment; Submersible - Pull & Stack	0	EA	$ 420.00	$ -
Surface Completion; 8" Field Grade - Removal	1	EA	$ 300.00	$ 300.00
Surface Completion; 12" Flush Grade - Removal	0	EA	$ 400.00	$ -
Surface Completion; Patch with Redi Mix Concrete (Up to 3' x 3')	0	EA	$ 50.00	$ -
Abandonment Crew Standby ('Client' Directed Work Stoppage..)	0	HR	$ 225.00	$ -
Subtotal				**$ 1,110.00**

Item	Quantity	Unit	Cost	Price
Pricing Breakdown - IDW Containment and Site Security				
Forklift & Tilt-Hopper; Transportation (R/T)	Included	EA	Included	Included
Forklift & Tilt-Hopper; Rental (Handle Drill Cuttings..)	Included	DY	Included	Included
55 Gallon 17H Drum	0	EA	$ 60.00	$ -
Visqueen Plastic Roll	6	EA	$ 160.00	$ 960.00
20 Yard Roll-off Bin; Transportation	0	HR	Cost + 20%	$ -
20 Yard Roll-off Bin; Plastic Liner	0	EA	Cost + 20%	$ -
20 Yard Roll-off Bin; Daily Rental	0	DY	Cost + 20%	$ -
20 Yard Roll-off Bin; Profiling Fee	0	EA	Cost + 20%	$ -
20 Yard Roll-off Bin; Disposal Fee	0	EA	Cost + 20%	$ -
6,500 Gallon Baker Tank; Transportation	0	EA	Cost + 20%	$ -
6,500 Gallon Baker Tank; Daily Rental	0	DY	Cost + 20%	$ -
5,000 Gallon Vacuum Truck Service (Gate to Gate)	0	HR	Cost + 20%	$ -
Well Site Protection; Free Standing Chain Link Fencing	0	EA	Cost + 20%	$ -
Well Site Protection; Security Guard (M-F; 5:00pm-7:00am)	0	DY	Cost + 20%	$ -
Well Site Protection; Security Guard (S-S; 24-Hours)	0	DY	Cost + 20%	$ -
Subtotal				**$ 960.00**

'YJD' Proposal Assumptions & Conditions:

1.) 'Client' to provide all Local, State, Federal project specific permits.
2.) All working locations are to be clear of any and all overhead & subsurface utilities.
3.) All working locations are accessible by way of 2-wheel drive truck mounted equipment.
4.) Profiling and disposal of all well abandonment debris & fluids generated will be the responsibility of the 'Client'.
5.) An equipped 'Client' arranged/approved on-site water supply source will be made available phases fo the project.
6.) Schedule/Pricing is based on a single rig operation; utilizing one (1) crew, working +/- 10/hour shifts, working a 5/on (Days) 2/off (Days) work schedule (M-F; Including Mob/Demob/Travel Time).
7.) Project is not subject to surcharges for Union/Davis Bacon/Prevailing labor rates.
8.) Rig standby due to unreadiness of the working locations or 'Client' delays will be billed at the provided hourly rate.
9.) If the project encounters difficulties beyond our control or if the scope of work is altered, 'YJD' reserves the right to renegotiate the price.
10.) Materials; due to the market price fluctuations of steel and petroleum based products; 'YJD' cannot guarantee the price of the materials required to complete the project beyond a period of 10-working days from the date in which the pricing is provided. In the event that a material price increase occurs; 'YJD' reserves the right to pass on the difference in the form of a revised proposal or by using the change order process.
11.) EIA Fuel Use Market Adjustment; due to the current price fluctuations of petroleum products 'YJD' has based the provided pricing on the most recent available weekly retail gasoline and diesel prices as reported by the Energy Information Administration ('EIA' - Official Energy Statistics from the US Government). 'YJD' has used the reported area average of ($4.35-Gallon) to calculate it's bid; in the event that the cost of fuel increases prior to the start and/or during the course of the project 'YJD' will invoice for the additional costs on a per-day basis. The per-day charge will be based on the difference of the fuel cost per-gallon at the time of bid; plus 20% mark-up verses the actual cost per-gallon during the time period in which the project is completed.

*NOTE: The multiplier to calculate the fuel use market adjustment on a per-day basis is based on the equipment package utilized; for this bid the daily multiplier is based on a fixed amount of 50-gallons.
12.) This proposal is valid for (60) days from the above date.

All services rendered will be billed promptly upon completion of work. Terms are net **thirty (30) days** unless otherwise agreed in writing in advance. A delinquency charge of 1.5% per month will apply to all past due invoices, unless a lower rate is required by law. Client agrees to pay all court costs and attorneys fees, should court proceedings be initiated or attorneys be retained to collect past due amounts.

We at Yellow Jacket Drilling Services thank you for the opportunity to provide this proposal. If you have any questions, or if we can be of any further assistance please do not hesitate to contact us at (602) 453-3252. We look forward to hearing from you soon.

Sincerely,
Yellow Jacket Drilling Services, LLC

John Truax

John Truax

Acceptance of all outlined pricing, terms and conditions:

Company Name:_________________________________

Authorized Representative (Name & Title):____

Signature:_________________________________

New rates form verbal with Paul from Yellow Jacket on 12/28/09 at 4:30 pm.

Yellow Jacket Drilling Services, LLC
P. O. Box 801
Gilbert, Arizona 85299

Telephone: (602) 453-3252
Fax: (602) 453-3258

Preliminary Project Estimate

Date: 22-Dec-09
Quote No : 09-1258AZ

For : ERM
Type of Project : Well Ins[...] $42.00 a foot
Project Name : PGA
Location : Goodyear, AZ

Assume 3 days per well

Total Feet of Drilling Required (2 ea. x 135' 270

Quantity	Description	Unit Cost		Total
TASK 1	**Two (2) - Well Installation w/ the Speedstar CH50K ARCH Drill Rig** **(Includes all labor, material & equipment)**			
1	Preparation Cost / Mobilization & Demobilization of the Speedstar CH50K ARCH Drill Rig	$2,500.00	ea.	$2,500.00
270	Feet of Drilling with the Speedstar CH50K Drill Rig (Includes split spoon sampling 10' int. / brass sleeves & caps)	$48.00	ft.	$12,960.00
270	Feet of Well Installation (Includes labor & materials / 4" dia. Sch. 40 PVC)	$28.00	ft.	$7,560.00
2	Surface Completion / 12" flush mount	$350.00	ea.	$700.00
0	Stand-by for reason beyond our control	$350.00	hr.	$0.00
5	Fork Lift & Tilt Hopper Rental	$250.00	day	$1,250.00
2	AZ Dept of Water Resources - Permitting	$200.00	ea.	$400.00
5	Service Vehicle / Decon Trailer	Incl.		Incl.
5	Water Dog or Additional Water Truck Unit for Transport of Water	$250.00	day	$1,250.00

$250.00

Yellow Jacket Drilling assumes all boring locations are accessible to a standard rubber tire, truck mounted drill rig & support equipment. YJD assumes all borehole cuttings will placed into "Client" provided roll off. All fluids generated during drilling, development & decon will placed into facility provided by the "Client". YJD has assumed NO costs associated will IDW storage or disposal of soil or fluids in this quotation.

Total Estimated Cost → **$26,620.00**

Average Cost Per Foot **$98.59**

Yellow Jacket Drilling (YJD) Proposal Assumptions & Conditions:

1.) All drilling locations are to be clear of any and all overhead & subsurface utilities (i.e. Bluestake, One Call, Underground Alert).
2.) Profiling and disposal of all soil cuttings and fluids generated will be the responsibility of the 'Client.'
3.) Any required traffic control and site security during all working & non-working hours will be provided by the 'Client.'
4.) Project is not subject to surcharges for Union/Davis Bacon/Prevailing labor rates.
5.) If the project encounters difficulties beyond our control or if the scope of work is altered, YJD reserves the right to renegotiate the price.
6.) This proposal is valid for sixty (60) days from the above date.

All services rendered will be billed promptly upon completion of the work. Terms are net thirty (30) days unless otherwise agreed in writing in advance.

Yellow Jacket Drilling would like to thank you for this opportunity to provide the enclosed cost estimate. If you have any questions, or if we may be of any further assistance, please do not hesitate to contact us at 602-453-3252. We look forward to hearing from you soon.

Sincerely,
Yellow Jacket Drilling

Paul McAlpine
Project Manager

Acceptance of all outlined pricing, terms and conditions:

Company Name:____

Authorized Representative (Name & Title):____

Signature:____

Layne Christensen Company
12030 E. Riggs Road
Chandler, Arizona 85249
Office: 480.895.9336
Fax: 480.895-8699

Project Estimate

Company:	**ERM**	**Date:**	**November 4, 2009**
Contact:	**Jason Hilker, G.I.T.**	**Project:**	**Iron Injection wells**
Address:	**7272 E. Indian School Rd., Suite 100**	**Location:**	**Goodyear, AZ**
City:	**Scottsdale**	**Estimated By:**	**James Stephens**
State:	**Arizona**	**Proposal Number:**	
Zip Code:	**85251**	**Estimated Footage:**	**270**
Phone:	**480 988-2401**	**Average Depths:**	**135**
FAX:	**480 998-2106**	**Number of Holes:**	**2**
Email:	jason.hilker@erm.com		

Description	Unit	Quantity	Cost	Total
Mobilization and demobilization of a AP-1000 dual-wall percussion hammer rig, support equipment and crew	Each	1	$1,000.00	$1,000.00
Split spoon sampling	Each	20	$65.00	$1,300.00
Drilling with the AP-1000 percussion hammer drill, nominal 9"	Foot	270	$25.00	$6,750.00
Miscellaneous drill rig time to move between locations, containerize drill cuttings, rig up /down, decontamination, clean site, etc	Hour	2	$325.00	$650.00
Well construction materials including 4" Sch-40 PVC casing, skiagrout and labor	Foot	270	$39.00	$10,530.00
Client directed stand-by time	Hour	4	$250.00	$1,000.00
Forklift with tilt-hopper	Day	5	$275.00	$1,375.00
Surface Completions 12" flush mounted	Each	2	$650.00	$1,300.00
Saw cutting (if needed)	Hour	0	$85.00	$0.00
Air knife (if needed)	Hour	0	$210.00	$0.00
ADWR permits	Each	2	$150.00	$300.00
All activities of pump rig and operator to assist client	Hour	60	$175.00	$10,500.00
Water Dog Trailer	Day	5	$250.00	$1,250.00
Miscellaneous equipment and materials consumed on project	Cost + 25%			
			Total Estimated Cost	**$35,955.00**

1) Subject to review of HASP.
2) Availability of manpower and equipment.
3) Actual cost based upon actual quantities consumed.
4) Utility clearance by others.
5) Storage, transport and disposal of drill cuttings and fluids by others.
6) Subject to attached contract terms and conditions.
7) Pricing is valid for 30 days from date.
8) Plus any applicable taxes.

Comments:

Client to provide containment for water and IDW.

Utility clearance, water, roll-offs and waste disposal by others

Year	nZVI	ZVI			
1	$165,734	$351,558	2.121218	$185,824	1.121218
2	$175,557	$365,901	2.084229	$190,344	1.084229
3	$105,303	$207,128	1.966972	$101,825	0.966972
4	$95,480	$195,050	2.042836	$99,570	1.042836
Total	$542,074	$1,119,637	2.065469	$577,563	1.065469
$ per frac	1973.02381	2117.819277			
$ per day	11838.14286	10339.94118			

nZVI Jet Fracturing

4 Year Total	$542,074

Year 1

Wells: 9
Fractures: 84
Mob Days: 6
Working Days: 14
Days Off: 4
Total Days: 24

Year 1				
Item	**Unit**	**# Units**	**Rate**	**Subtotal**
Mobilization	LS	1	15800	$15,800
Periodic Mobilizations	Each	1	4000	$4,000
Per Diem	Day	18	528	$9,504
Jet-Fractures (600 gal)	Fracture	84	1420	$119,280
FRx Packer System	Day	14	75	$1,050
FRx Water Blaster	Day	14	350	$4,900
FRx Fracture Pump/Rig	Day	14	350	$4,900
H&S Supplies	LS	1	400	$400
Decon	LS	1	500	$500
Waste Management	LS	1	400	$400
Misc.	Each	1	5000	$5,000
Standby-Equipment Only	Day	0	900	$0
Standby- Personnel Onsite	Hour	0	350	$0
		Year 1	**Total**	**$165,734**

Year 2
Wells: 15
Fractures: 90
Mob Days: 6
Working Days: 15
Days Off: 4
Total Days: 25

Year 2				
Item	**Unit**	**# Units**	**Rate**	**Subtotal**
Mobilization	LS	1	15800	$15,800
Periodic Mobilizations	Each	1	4000	$4,000
Per Diem	Day	19	528	$10,032
Jet-Fractures (600 gal)	Fracture	90	1420	$127,800
FRx Packer System	Day	15	75	$1,125
FRx Water Blaster	Day	15	350	$5,250
FRx Fracture Pump/Rig	Day	15	350	$5,250
H&S Supplies	LS	1	400	$400
Decon	LS	1	500	$500
Waste Management	LS	1	400	$400
Misc.	Each	1	5000	$5,000
Standby- Equipment Only	Day	0	900	$0
Standby- Personnel Onsite	Hour	0	350	$0
		Year 1	**Total**	**$175,557**

Year 3
Wells: 15
Fractures: 51
Mob Days: 6
Working Days: 9
Days Off: 2
Total Days: 17

Year 3				
Item	**Unit**	**# Units**	**Rate**	**Subtotal**
Mobilization	LS	1	15800	$15,800
Per Diem	Day	11	528	$5,808
Jet-Fractures (600 gal)	Fracture	51	1420	$72,420
FRx Packer System	Day	9	75	$675
FRx Water Blaster	Day	9	350	$3,150
FRx Fracture Pump/Rig	Day	9	350	$3,150
H&S Supplies	LS	1	400	$400
Decon	LS	1	500	$500
Waste Management	LS	1	400	$400
Misc.	Each	1	3000	$3,000
Standby- Equipment Only	Day	0	900	$0
Standby- Personnel Onsite	Hour	0	350	$0
		Year 1	**Total**	**$105,303**

Year 4
Wells: 15
Fractures: 45
Mob Days: 6
Working Days: 8
Days Off: 2
Total Days: 16

Year 4				
Item	**Unit**	**# Units**	**Rate**	**Subtotal**
Mobilization	LS	1	15800	$15,800
Per Diem	Day	10	528	$5,280
Jet-Fractures (600 gal)	Fracture	45	1420	$63,900
FRx Packer System	Day	8	75	$600
FRx Water Blaster	Day	8	350	$2,800
FRx Fracture Pump/Rig	Day	8	350	$2,800
H&S Supplies	LS	1	400	$400
Decon	LS	1	500	$500
Waste Management	LS	1	400	$400
Misc.	Each	1	3000	$3,000
Standby- Equipment Only	Day	0	900	$0
Standby- Personnel Onsite	Hour	0	350	$0
		Year 1	**Total**	**$95,480**

nZVI Jet Fracturing

4 Year Total	$1,119,637

Year 1

Wells: 18
Fractures: 166
Mob Days: 6
Working Days: 34
Days Off: 13
Total Days: 53

Year 1				
Item	**Unit**	**# Units**	**Rate**	**Subtotal**
Mobilization	LS	1	15800	$15,800
Periodic Mobilizations	Trip	2.5	5000	$12,500
Per Diem	Day	47	704	$33,088
Fractures (2,000 lbs. ZVI)	Fracture	166	1420	$235,720
FRx Packer System	Day	34	75	$2,550
FRx Water Blaster	Day	34	350	$11,900
FRx Fracture Pump/Rig	Day	34	350	$11,900
H&S Supplies	LS	1	1000	$1,000
Decon	LS	1	500	$500
Waste Management	Fracture	166	100	$16,600
Misc.	Each	2	5000	$10,000
Standby-Equipment Only	Day	0	900	$0
Standby- Personnel Onsite	Hour	0	350	$0
		Year 1	**Total**	**$351,558**

Year 2

Wells: 30
Fractures: 174
Mob Days: 6
Working Days: 35
Days Off: 14
Total Days: 55

Year 2				
Item	**Unit**	**# Units**	**Rate**	**Subtotal**
Mobilization	LS	1	15800	$15,800
Periodic Mobilizations	Each	2.5	5000	$12,500
Per Diem	Day	49	704	$34,496
Fractures (2,000 lbs. ZVI)	Fracture	174	1420	$247,080
FRx Packer System	Day	35	75	$2,625
FRx Water Blaster	Day	35	350	$12,250
FRx Fracture Pump/Rig	Day	35	350	$12,250
H&S Supplies	LS	1	1000	$1,000
Decon	LS	1	500	$500
Waste Management	Fracture	174	100	$17,400
Misc.	Each	2	5000	$10,000
Standby- Equipment Only	Day	0	900	$0
Standby- Personnel Onsite	Hour	0	350	$0
		Year 1	**Total**	**$365,901**

Year 3

Wells: 30
Fractures: 96
Mob Days: 6
Working Days: 20
Days Off: 7
Total Days: 33

Year 3				
Item	**Unit**	**# Units**	**Rate**	**Subtotal**
Mobilization	LS	1	15800	$15,800
Periodic Mobilizations	Each	1	5000	$5,000
Per Diem	Day	27	704	$19,008
Fractures (2,000 lbs. ZVI)	Fracture	96	1420	$136,320
FRx Packer System	Day	20	75	$1,500
FRx Water Blaster	Day	20	350	$7,000
FRx Fracture Pump/Rig	Day	20	350	$7,000
H&S Supplies	LS	1	400	$400
Decon	LS	1	500	$500
Waste Management	Fracture	96	100	$9,600
Misc.	Each	1	5000	$5,000
Standby- Equipment Only	Day	0	900	$0
Standby- Personnel Onsite	Hour	0	350	$0
		Year 1	**Total**	**$207,128**

Year 4

Wells: 30
Fractures: 90
Mob Days: 6
Working Days: 18
Days Off: 7
Total Days: 31

Year 4				
Item	**Unit**	**# Units**	**Rate**	**Subtotal**
Mobilization	LS	1	15800	$15,800
Periodic Mobilizations	Each	1	5000	$5,000
Per Diem	Day	25	704	$17,600
Fractures (2,000 lbs. ZVI)	Fracture	90	1420	$127,800
FRx Packer System	Day	18	75	$1,350
FRx Water Blaster	Day	18	350	$6,300
FRx Fracture Pump/Rig	Day	18	350	$6,300
H&S Supplies	LS	1	400	$400
Decon	LS	1	500	$500
Waste Management	Fracture	90	100	$9,000
Misc.	Each	1	5000	$5,000
Standby- Equipment Only	Day	0	900	$0
Standby- Personnel Onsite	Hour	0	350	$0
		Year 1	**Total**	**$195,050**

FRx, Inc.
P.O. Box 498292
Cincinnati, OH
45249-8292

(513) 469 6040 fax (513) 469 6041
www.frx-inc.com

Technical Approach and Cost Estimate – Jet-Assisted Hydraulic Fracturing with nZVI

Submitted to: Haley & Aldrich, Inc.
Site: PGA North
November 22, 2011

FRx submits this technical approach and cost estimate to support a project Haley & Aldrich, Inc. (H&A) is undertaking referenced as PGA North in Goodyear, Arizona. FRx will provide hydraulic fracturing expertise and services to support that project. Hydraulic fracturing to support subsurface remediation has been the principal business of FRx since its founding in 1994. FRx has created more than 3000 hydraulic fractures at more than 200 sites for almost 20 years.

Previous studies of this site have shown our Jet-Assisted Hydraulic Fracturing technology applicable to the site conditions and project goals.

In general, FRx will deploy methods that derive from the techniques developed by the US EPA during the course of research and development projects conducted in the 1980's and early 1990's. These methods have been adapted for deeper applications with challenging drilling and are referred to as "Jet-Fracturing". The changes involve the use of high pressure water jets, zone isolating packers, and dedicated PVC casings. See Appendices 1 and 2 for a more detailed description of jet fracturing.

Site Description

The site is located in Goodyear, Arizona. The site is fence protected, open area, and the ground surface is asphalt, gravel, or dirt. No water is available onsite. Previously, H&A provided water in a rented poly tank.

Drilling

The first step for this project, the installation of the wells, will be completed by H&A using drilling techniques necessary to penetrate the formation. A four-inch diameter flush threaded schedule 40 PVC casing will be installed in the boring along with centralizers at 20-foot intervals. The boring will be pressure trimmie grouted from borehole bottom to top using a Portland Cement/Bentonite grout mix. A four-inch locking expansion plug and lock will be installed along with an eight-inch diameter flush well cover.

Well counts are listed below.

Significant Items to be Supplied by Haley and Aldrich

Wells – H&A will subcontract well installation prior to FRx arrival.

Water – H&A will supply a "rain for rent" poly tank for water. Also, this water will be de-oxygenated via nitrogen gas by H&A. FRx will assist with this effort. Also, FRx will manage nitrogen gas to our tanks and pump hoppers if deemed necessary by H&A.

Access – H&A will arrange for access to the site.

Injectate – H&A will supply onsite the nZVI amendment in totes. FRx will assist in mixing and transferring these totes.

Injection Schedule

nZVI - Year 1	Wells	frx/well	total frx	gal/frx
red	3	11	33	600
orange	5	9	45	600
blue	1	6	6	600
yellow	0	3	0	600
Total	**9**		**84**	
nZVI - Year 2				
red	0	11	0	600
orange	2	9	18	600
blue	11	6	66	600
yellow	2	3	6	600
Total	**15**		**90**	
nZVI - Year 3				
red	0	11	0	600
orange	0	9	0	600
blue	2	6	12	600
yellow	13	3	39	600
Total	**15**		**51**	
nZVI - Year 4				
red	0	11	0	600
orange	0	9	0	600
blue	0	6	0	600
yellow	15	3	45	600
Total	**15**		**45**	

Fracturing

The FRx downhole tooling will consist of two packers straddling the target interval, a supply line for 10,000psi water jets to cut through the PVC, grout, and several feet into the formation, and an nZVI slurry delivery hose. The downhole tools will be inserted into the well to the target depth. The packers will then be inflated. The water jets will be activated for approximately one minute and then fifteen second intervals every five minutes during the fracture. After the initial one minute jetting, the nZVI slurry pump will be initiated. The downhole tools will then be moved to the next fracture interval. We expect to create no waste material except for the occasional hose purge.

Equipment

The following equipment will be supplied by FRx.

- Personnel vehicles
- Pump hoist truck (wireline)
- Packer system
- Water blaster
- Injection nZVI pump
- Transfer and mixing "trash" pumps, hoses, fittings, valves, and pressure gauges

Personnel

Drilling will be supplied by H&A.

Fracturing work will require the efforts of three persons. These personnel will share responsibilities operating a water blaster, pump hoist truck, injection pump, mixing equipment, and the other necessary equipment. One of these will be responsible for QA/QC, health and safety, and reporting to Haley & Aldrich.

All personnel are trained as hazardous waste site workers per 29 CFR 1910 and 29 CFR 1926. All are subject to annual medical monitoring and are certified to use respirators. All are United States citizens.

APPENDIX 1

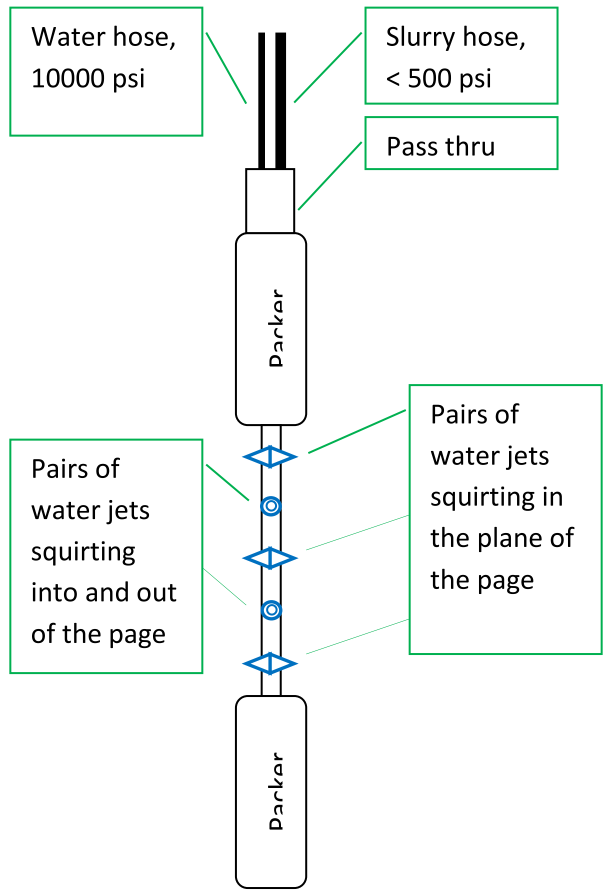
Jet-Fracturing

Jet Fracturing Through Dedicated Wells

FRx, Inc.
P.O. Box 498292
Cincinnati, OH
45249-8292
(513) 469 6040 fax (513) 469 6041
www.frx-inc.com

Jet-assisted fracturing utilizes the kinetic energy of high-pressure water jets to distribute injected slurry throughout the soil matrix. These effects occur in addition to forms that follow from hydraulic fracturing phenomena that may happen simultaneously. In addition, the energy of the jets assists in the penetration of dense or tough soils. The technology was developed and used successfully at a site in Bordentown, New Jersey. It has since been deployed at several other sites.

The Fracturing Lance



The jet fracturing lance consists of a pair of packers straddling a collection of waterblast nozzles that are pointed horizontally. The nozzles are arranged in pairs to counterbalance the recoil force of the individual nozzles. (Certainly other counterbalance configurations such as triplets and quads are possible conceptually, but may require nearly infeasible mechanical arrangements.) The lance used for the Bordentown project used five pairs of nozzles spaced a foot apart. Fewer or somewhat greater number of pairs are possible, and the spacing can be changed easily. Also, the Bordentown lance pointed the nozzles in two directions as shown (both parallel and perpendicular to the plane of the schematic.) Alternatively, the nozzles could be arranged in the same plane to effect a “wall” action, or a variety of azimuths could be elected.

Water is delivered to the lance via a standard waterblast hose. It enters the packer through a pass-thru that we have fabricated for that purpose. From the pass-thru to the bottom jet, the water is conducted thru a carefully selected network of high strength stainless steel tubing.

Treatment slurry is delivered to the lance through a conventional injection service hose. That hose also connects to the pass-thru block, which directs the slurry into the straddled interval.

Application

The jet fracturing process is performed in 4-inch PVC wells. The wells are constructed by a method that ensures a competent grout seal in the annulus between the casing and the borehole, thus guaranteeing that material injected at any particular elevation does not have a free pathway to overlying or underlying intervals. Mud rotary and air rotary methods have proven to be successful, and other methods should be satisfactory.

The jet-assisted fracturing lance directs its 10,000-psi jets against the inside of the PVC casing. The jets have sufficient strength to penetrate the solid PVC casing and the surrounding grout. Turbulence outside of the casing and grout sheath mixes the simultaneously injected slurry with soil. Work done at the DOE Portsmouth facility with a similar lance showed that the disrupted zone extended as much as five feet from the parent well – a result consistent with well jetting work done at the US EPA Center Hill Laboratory in the early 1990's. In addition, the delivery of fluid (the sum of jetting water and slurry) induces stresses that result in nucleation of small hydraulic fractures that result in farther distribution of material. As a result, monitoring wells offset by as much as 25 feet may be impacted immediately during the injection process.

After delivering a designed volume of slurry to the interval, the packers and the lance can be moved upwards along the well to treat additional zones sequentially.

High Pressure Water Unit

This package typically is delivered on a utility trailer. Its major components include a diesel engine, a triplex pump, a fuel tank, and a water surge tank. These units weigh 8500 lb. Skid mount units are manufactured, but are less readily available. Water pressurized by this pump is conducted in hoses designed for waterblasting service. The operator of this unit stands on the ground, so the operating footprint is about 20 feet X 12 feet.

Treatment Material Pump

The pump used for this service should be compatible with the remediation materials as well as capable of accomplishing the desired rate and requisite pressure. Slurries of abrasive granular materials, such as iron, preclude the use of many fluid pumps but can be managed by piston pumps such as the one pictured here. Progressing cavity pumps also can delivery slurries. Liquid treatment materials can be pumped with more commonly available equipment.

Injection pressures typically do not exceed a few hundred psi, but each site will impose its particular requirements. The volumetric rate should exceed 25 gpm for adequate process performance as well as cost-effective deployment.

APPENDIX 2

Creating Permeable Reactive Zones with Jet Fracturing

Creating Permeable Reactive Zones With Jet Fracturing

FRx, Inc.
P.O. Box 498292
Cincinnati, OH
45249-8292

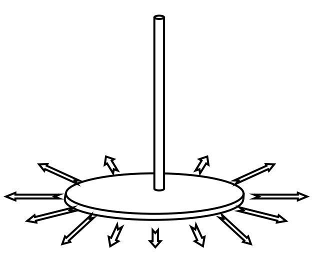
(513) 469 6040 fax (513) 469 6041
www.frx-inc.com

A traditional permeable reactive barrier (PRB) comprises a subsurface body of active material that is constructed to intercept groundwater flow and to destroy dissolved contaminants during transit through it. One common embodiment involves filling a trench with granular reagent such as iron. While perfectly satisfactory for shallow applications in open spaces, trenching requires broad surface access and requires removal of overburden soil and rock that may not be contaminated. Also trenches cannot be advanced efficiently beyond limiting depth.

Alternatively, hydraulic fracturing can be used to construct two dimensional structures that, when properly oriented, intercept in situ flux like a PRB. Fractures can be created at any depth of interest within environmental restoration, and a small set of wells can be utilized to create the fractures that compose the intercepting, reactive zones. The key challenges to this application of hydraulic fracturing are establishing the orientation of the fracture and assuring a continuous, holiday-free sheet-like structure.

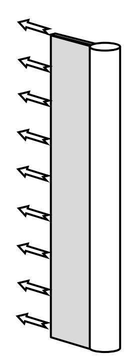
Creation of Hydraulic Fractures

Hydraulic fractures are created when fluid pressure generates stress that overcomes the mechanical strength of the surrounding earth media – either soil or bedrock. The orientation of a nucleated fracture depends upon how pressure is applied. For instance, a horizontal fracture can be created by pressurizing a horizontal disk-shaped cavity that intersects a short segment of a wellbore, as suggested by the sketch at the left. FRx routinely uses this approach to create discrete, sand-filled fractures to enhance delivery of treatment materials into low permeability media. However, a horizontal feature does not serve to directly intercept lateral flux in a very permeable system.



Model of the creation of a horizontal, symmetrical fracture to serve as a fluid distributor for delivery of substrate solution into low permeability media.

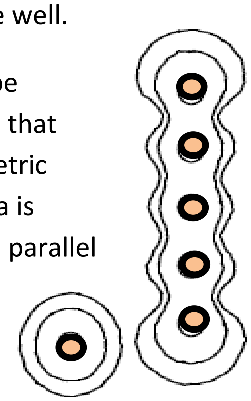
A vertical fracture will nucleate if a long, vertical slot is created along the wall of a borehole and pressurized. By controlling the direction of the slot, the azimuth of the fracture can be established, as suggested by the sketch to the right, and oriented to intercept groundwater flow. However, maintaining a stable, open boring to conduct treatment material into the resulting fracture can prove difficult. Furthermore, in tall targets, a single vertical kerf does not offer much control over the vertical distribution, and a particular range of the target may receive a disproportionate share of treatment material.



A vertically oriented fracture can propagate from a vertical kerf along a well.

Note that both these methods seek to exploit a small, two dimensional shape to effect a larger two dimensional shape (the PRB) of the same orientation - the symmetric horizontal fracture follows from the horizontal disk while the vertical fracture follows from the vertical kerf. There is, however, another way to create the appropriate in situ stress field for a desired fracture. Rather than apply pressure through a single, discrete geometric shape, we can rely upon the summation of stresses around a multitude of single, essentially line-like, features that we create from the well.

In particular, the appropriate state of stress for nucleating a vertical fracture can be developed by the summation of a series of parallel, pressurized horizontal tunnels that emanate from the borehole. The stress around a single horizontal tunnel is symmetric around the axis of the tunnel, and the mechanical failure of the surrounding media is along an arbitrary plane that includes the axis of the tunnel. In contrast, when five parallel tunnels are pressurized, stress accumulates between the tunnels and effectively defines a plane, which will serve as the root of the fracture. The adjacent sketch conveys these principles.

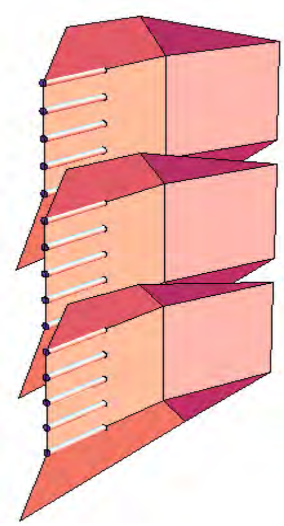


Contours of stress induced by pressurizing a single cylinder (left) and five parallel cylinders (right.)

The task of creating the horizontal tunnels can be accomplished easily with a high pressure water jet. The kinetic energy of a 10,000 psi water jet rapidly erodes a tunnel as deep as several feet even in heavy, dense soils such as clays and silts. Such pressure also can cut through PVC and grout in about 15 seconds, which allows the jet to be deployed at discrete points within a PVC casing. Use of casing maintains the stability of the borehole.

Since the jets create discreet holes in the PVC casing, subsets of holes can be addressed individually – an array of pressurization tunnels does not need to be created simultaneously from the top to the bottom of the target interval. A small collection of jets can be isolated by a pair of packers, and discrete vertical fractures nucleated along segments of the boring. This gives better control over the placement of treatment materials. For instance, treatment materials can be omitted from impermeable units that intersect the injection location while adequate fractures can be created in underlying as well as overlying targets.

Recognizing the natural heterogeneity and irregularity within soil units, we cannot expect all of the induced vertical fractures to align. Some will, while others will diverge or propagate in parallel but distinct planes. For example, the adjacent schematic suggests how the essentially vertical fractures created from three groups of five jetted tunnels might nest and overlap. In reality, fractures extend substantially farther than the extent of the nucleation tunnels. Fractures have three dimensional character, as suggested in the sketch, although certainly more irregular and curved than depicted with the several regular polygons. A significant portion of the fracture panels will remain within the plane of nucleation even though native in situ stress may prefer another azimuth. If the fractures do not intersect and accumulate, then the parallel sheets will offer a collective residence time to the intercepted groundwater flux.



An illustration of the concept of nearly coincident vertical fractures. Size of nucleation tunnels relative to fracture extent exaggerated to better illustrate the role of governing the orientation of the fractures.

APPENDIX 3

Schedule and Costs

Schedule

The following schedules are based on 1 day of set-up, our expectation to be able to complete six (6) fracture injections per day, days off, and 1 day of site restoration. The six days of mobilization per event are not included below.

Year 1

Wells: 9

Fractures: 79

Working Days: 14

Total Days: 18

Year 2

Wells: 15

Fractures: 88

Working Days: 15

Total Days: 19

Year 3

Wells: 15

Fractures: 51

Working Days: 9

Total Days: 11

Year 4

Wells: 15

Fractures: 45

Working Days: 8

Total Days: 10

Costs

The following costs are offered based on today's prices of supplies and materials and may need to be adjusted for years 2, 3, and 4.

Year 1				
Item	**Unit**	**# Units**	**Rate**	**Subtotal**
Mobilization	LS	1	15800	$15,800
Periodic Mobilizations	Each	1	4000	$4,000
Per Diem	Day	18	528	$9,504
Jet-Fractures (600 gal)	Fracture	84	1420	$119,280
FRx Packer System	Day	14	75	$1,050
FRx Water Blaster	Day	14	350	$4,900
FRx Fracture Pump/Rig	Day	14	350	$4,900
H&S Supplies	LS	1	400	$400
Decon	LS	1	500	$500
Waste Management	LS	1	400	$400
Misc.	Each	1	5000	$5,000
Standby- Equipment Only	Day	0	900	$0
Standby- Personnel Onsite	Hour	0	350	$0
		Year 1	**Total**	**$165,734**

Year 2				
Item	**Unit**	**# Units**	**Rate**	**Subtotal**
Mobilization	LS	1	15800	$15,800
Periodic Mobilizations	Each	1	4000	$4,000
Per Diem	Day	19	528	$10,032
Jet-Fractures (600 gal)	Fracture	90	1420	$127,800
FRx Packer System	Day	15	75	$1,125
FRx Water Blaster	Day	15	350	$5,250
FRx Fracture Pump/Rig	Day	15	350	$5,250
H&S Supplies	LS	1	400	$400
Decon	LS	1	500	$500
Waste Management	LS	1	400	$400
Misc.	Each	1	5000	$5,000
Standby- Equipment Only	Day	0	900	$0
Standby- Personnel Onsite	Hour	0	350	$0
		Year 1	**Total**	**$175,557**

Year 3				
Item	**Unit**	**# Units**	**Rate**	**Subtotal**
Mobilization	LS	1	15800	$15,800
Per Diem	Day	11	528	$5,808
Jet-Fractures (600 gal)	Fracture	51	1420	$72,420
FRx Packer System	Day	9	75	$675
FRx Water Blaster	Day	9	350	$3,150
FRx Fracture Pump/Rig	Day	9	350	$3,150
H&S Supplies	LS	1	400	$400
Decon	LS	1	500	$500
Waste Management	LS	1	400	$400
Misc.	Each	1	3000	$3,000
Standby- Equipment Only	Day	0	900	$0
Standby- Personnel Onsite	Hour	0	350	$0
		Year 1	**Total**	**$105,303**

Year 4				
Item	**Unit**	**# Units**	**Rate**	**Subtotal**
Mobilization	LS	1	15800	$15,800
Per Diem	Day	10	528	$5,280
Jet-Fractures (600 gal)	Fracture	45	1420	$63,900
FRx Packer System	Day	8	75	$600
FRx Water Blaster	Day	8	350	$2,800
FRx Fracture Pump/Rig	Day	8	350	$2,800
H&S Supplies	LS	1	400	$400
Decon	LS	1	500	$500
Waste Management	LS	1	400	$400
Misc.	Each	1	3000	$3,000
Standby- Equipment Only	Day	0	900	$0
Standby- Personnel Onsite	Hour	0	350	$0
		Year 1	**Total**	**$95,480**

FRx, Inc.
P.O. Box 498292
Cincinnati, OH
45249-8292

(513) 469 6040 fax (513) 469 6041
www.frx-inc.com

Technical Approach and Cost Estimate – Traditional Hydraulic Fracturing with ZVI

Submitted to: Haley & Aldrich, Inc.
Site: PGA North
November 22, 2011

FRx submits this technical approach and cost estimate to support a project Haley & Aldrich, Inc. (H&A) is undertaking referenced as PGA North in Goodyear, Arizona. FRx will provide hydraulic fracturing expertise and services to support that project. Hydraulic fracturing to support subsurface remediation has been the principal business of FRx since its founding in 1994. FRx has created more than 3000 hydraulic fractures at more than 200 sites for almost 20 years.

FRx understands H&A is interested in exploring the option of injecting macro scale ZVI with our traditional fracturing techniques.

In general, FRx will deploy methods that derive from the techniques developed by the US EPA during the course of research and development projects conducted in the 1980's and early 1990's. These methods have been adapted for deeper applications requiring a granular injectate. The changes involve the use of high pressure water jets, zone isolating packers, and dedicated PVC casings.

Site Description

The site is located in Goodyear, Arizona. The site is fence protected, open area, and the ground surface is asphalt, gravel, or dirt. No water is available onsite. Previously, H&A provided water in a rented poly tank.

Drilling

The first step for this project, the installation of the wells, will be completed by H&A using drilling techniques necessary to penetrate the formation. A four-inch diameter flush threaded schedule 40 PVC casing will be installed in the boring along with centralizers at 20-foot intervals. The boring will be pressure trimmie grouted from borehole bottom to top using a Portland Cement/Bentonite grout mix. A four-inch locking expansion plug and lock will be installed along with an eight-inch diameter flush well cover.

Well counts are listed below.

Significant Items to be Supplied by Haley and Aldrich

Wells – H&A will subcontract well installation prior to FRx arrival.

Water – H&A will supply a “rain for rent” poly tank for water. Also, this water will be de-oxygenated via nitrogen gas by H&A. FRx will assist with this effort. Also, FRx will manage nitrogen gas to our tanks and pump hoppers if deemed necessary by H&A.

Access – H&A will arrange for access to the site.

Injectate – H&A will supply onsite the ZVI amendment in 2,000 pound super sacks.

Injection Schedule

ZVI - Year 1	Wells	frx/well	total frx	lbs/frx
red	8	11	88	2,000
orange	6	9	54	2,000
blue	4	6	24	2,000
yellow	0	3	0	2,000
Totals	18	29	166	
ZVI - Year 2	**Wells**	**frx/well**		
red	0	11	0	2,000
orange	4	9	36	2,000
blue	20	6	120	2,000
yellow	6	3	18	2,000
Totals	30	29	174	
ZVI - Year 3	**Wells**	**frx/well**		
red	0	11	0	2,000
orange	0	9	0	2,000
blue	2	6	12	2,000
yellow	28	3	84	2,000
Totals	30	29	96	
ZVI - Year 4	**Wells**	**frx/well**		
red	0	11	0	2,000
orange	0	9	0	2,000
blue	0	6	0	2,000
yellow	30	3	90	2,000
Totals	30	29	90	

Fracturing

The PVC casing, grout, and formation will be cut, or “notched”, by a spinning jet powered by 10,000 psi water. The next step, fracturing, will consist of two packers straddling the target interval and a ZVI slurry delivery hose. The downhole tools will be inserted into the well to the target depth, inflated, and the ZVI will be delivered to create a fracture. The downhole tools will then be removed and the notching tools will be reinserted for the next target interval. **We expect to create 50 gallons of waste water per fracture from the notching effort**.

Equipment

The following equipment will be supplied by FRx.

- Personnel vehicles
- Pump hoist truck (wireline)
- Packer system
- Water blaster
- Fracture Rig
- **Off Road Forklift**
- Transfer and mixing "trash" pumps, hoses, fittings, valves, and pressure gauges

Personnel

Drilling will be supplied by H&A.

Fracturing work will require the efforts of four persons. These personnel will share responsibilities operating a water blaster, pump hoist truck, injection pump, mixing equipment, forklift, and the other necessary equipment. One of these will be responsible for QA/QC, health and safety, and reporting to Haley & Aldrich.

All personnel are trained as hazardous waste site workers per 29 CFR 1910 and 29 CFR 1926. All are subject to annual medical monitoring and are certified to use respirators. All are United States citizens.

Schedule

For the purpose of this schedule, we have assumed each fracture will contain 2,000 pounds of granular ZVI. The following schedules are based on 1 day of set-up, our expectation to be able to complete six (6) fracture injections per day, days off, and 1 day of site restoration. The six days of mobilization per event are not included below.

Year 1

Wells: 9

Fractures: 79

Working Days: 14

Total Days: 18

Year 2

Wells: 15

Fractures: 88

Working Days: 15

Total Days: 19

Year 3

Wells: 15
Fractures: 51
Working Days: 9
Total Days: 11

Year 4

Wells: 15
Fractures: 45
Working Days: 8
Total Days: 10

Costs

For the purpose of this cost estimate we have assumed each fracture will contain 2,000 pounds of granular ZVI. The following costs are offered based on today's prices of supplies and materials and may need to be adjusted for years 2, 3, and 4.

Year 1				
Item	**Unit**	**# Units**	**Rate**	**Subtotal**
Mobilization	LS	1	15800	$15,800
Periodic Mobilizations	Trip	2.5	5000	$12,500
Per Diem	Day	47	704	$33,088
Fractures (2,000 lbs. ZVI)	Fracture	166	1420	$235,720
FRx Packer System	Day	34	75	$2,550
FRx Water Blaster	Day	34	350	$11,900
FRx Fracture Pump/Rig	Day	34	350	$11,900
H&S Supplies	LS	1	1000	$1,000
Decon	LS	1	500	$500
Waste Management	Fracture	166	100	$16,600
Misc.	Each	2	5000	$10,000
Standby-Equipment Only	Day	0	900	$0
Standby- Personnel Onsite	Hour	0	350	$0
		Year 1	**Total**	**$351,558**

Year 2				
Item	**Unit**	**# Units**	**Rate**	**Subtotal**
Mobilization	LS	1	15800	$15,800
Periodic Mobilizations	Each	2.5	5000	$12,500
Per Diem	Day	49	704	$34,496
Fractures (2,000 lbs. ZVI)	Fracture	174	1420	$247,080
FRx Packer System	Day	35	75	$2,625
FRx Water Blaster	Day	35	350	$12,250
FRx Fracture Pump/Rig	Day	35	350	$12,250
H&S Supplies	LS	1	1000	$1,000
Decon	LS	1	500	$500
Waste Management	Fracture	174	100	$17,400
Misc.	Each	2	5000	$10,000
Standby- Equipment Only	Day	0	900	$0
Standby- Personnel Onsite	Hour	0	350	$0
		Year 1	**Total**	**$365,901**

Year 3				
Item	**Unit**	**# Units**	**Rate**	**Subtotal**
Mobilization	LS	1	15800	$15,800
Periodic Mobilizations	Each	1	5000	$5,000
Per Diem	Day	27	704	$19,008
Fractures (2,000 lbs. ZVI)	Fracture	96	1420	$136,320
FRx Packer System	Day	20	75	$1,500
FRx Water Blaster	Day	20	350	$7,000
FRx Fracture Pump/Rig	Day	20	350	$7,000
H&S Supplies	LS	1	400	$400
Decon	LS	1	500	$500
Waste Management	Fracture	96	100	$9,600
Misc.	Each	1	5000	$5,000
Standby- Equipment Only	Day	0	900	$0
Standby- Personnel Onsite	Hour	0	350	$0
		Year 1	**Total**	**$207,128**

Year 4				
Item	**Unit**	**# Units**	**Rate**	**Subtotal**
Mobilization	LS	1	15800	$15,800
Periodic Mobilizations	Each	1	5000	$5,000
Per Diem	Day	25	704	$17,600
Fractures (2,000 lbs. ZVI)	Fracture	90	1420	$127,800
FRx Packer System	Day	18	75	$1,350
FRx Water Blaster	Day	18	350	$6,300
FRx Fracture Pump/Rig	Day	18	350	$6,300
H&S Supplies	LS	1	400	$400
Decon	LS	1	500	$500
Waste Management	Fracture	90	100	$9,000
Misc.	Each	1	5000	$5,000
Standby- Equipment Only	Day	0	900	$0
Standby- Personnel Onsite	Hour	0	350	$0
		Year 1	**Total**	**$195,050**

Custom Estimate Developed Especially for:

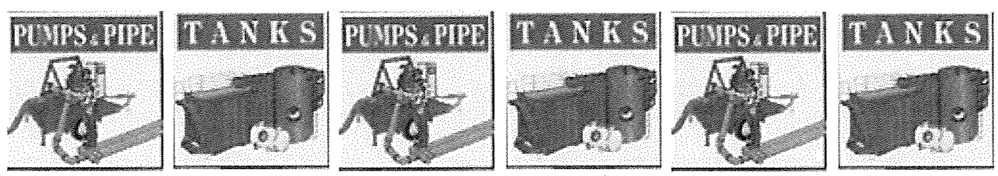
Jason Hilker
Erm West Inc
1777 Betelho Dr Ste 260
Walnut Creek, CA 94596
Phone: 480-998-2401

Prepared on 12/29/2009 by:

Rain for Rent

David Jewett
Cell: (602)725-7839
P O Box 11070
Chandler, AZ 85248
Phone: 480-895-9225
Fax: 480-895-0345

www.rainforrent.com



A benefit of doing business with Rain for Rent is the knowledge that our Engineering Department is behind the scenes, backing up our Sales Representatives to ensure that your project needs are met.

Rain for Rent Chandler

Rental Estimate

www.rainforrent.com

P O Box 11070
Chandler, AZ 85248
Phone: 480-895-9225
Fax: 480-895-0345

Estimate Number: 10-092-312895
Prepared By: David Jewett

Job Description:
Push potable water 1800ft into poly tanks. Customer will remove oxygen from water and inject into ground.

Customer: Erm West Inc

Customer ID: 920545
Address: 1777 Betelho Dr Ste 260
City/State: Walnut Creek, CA 94596
Contact: Jason Hilker
Office: 480-998-2401
Fax:

Location:
Litchfield rd and Goodyear rd
Goodyear, Az

Rental Sub Total: $2,996.40

Sub Total: $2,996.40

*The Terms and Conditions of the Rain For Rent Rental and Acute Hazardous Waste Agreements, Credit Application, Invoice and this estimate contain the complete and final agreement between Rain For Rent and Customer and no other agreement in any way modifying or adding to any of said Terms and Conditions will be binding upon Rain For Rent unless made In writing and signed by a Rain For Rent Corporate Officer.
*Payment terms are net 30 days from invoice date. A 1.5%month late charge will be made on any past due invoices.
*Estimate is valid for 30 days and is subject to credit approval.
*Availability subject to change without notice.
*Estimates are based on Customer supplied information and are subject to change based on actual requirements and usage.

Est. Delivery Hauling	$1,580.00
Est. Pick-up Hauling	$1,580.00
Est. Install Labor	$1,088.96
Est. Removal Labor	$878.64
Est. Services	$0.00
Est. Fuel Surcharge	$379.20

(Does Not Include Sales Tax)

Estimate Total: $8,503.20

Date Prepared: 12/29/2009

Valid Until: 1/28/2010

Customer ____________________

Date ____________________

If customer requires a PO# to process and submit payment, it must be supplied to Rain for Rent at the time of acceptance of this estimate.
Please insert Purchase Order number here: ____________________

By signing this estimate, customer represents that customer has read and agreed to all terms of this estimate, including those on Terms & Conditions page and those on the Additional Specifications page (if applicable).

Rain for Rent Chandler

www.rainforrent.com

P O Box 11070
Chandler, AZ 85248
Phone: 480-895-9225
Fax: 480-895-0345

Estimate Number: 10-092-312895

Application: Poly tank fill Materials: Potable Water Flow: 50-100gpm Suction Lift: 0 Friction Loss: >20

*Rain for Rent Cycle = 28 Days.
This estimate has not been flagged as PREVAILING WAGE.

Rental Items

Qty	Unit	Duration	Item	Description	Day	Week	*Cycle	Extension
3	Each	28 Day	+660506	TANK-POLY 4900 GAL	$17.25	$0.00	$0.00	$1,449.00
2	Each	28 Day	+670501	SPILLGUARD-12'X16'X1'	$12.75	$0.00	$0.00	$714.00
44	Jnt	1 *Cycle	976940	PIPE-IND-GRV 6x40 ALUM 83	$0.00	$0.00	$17.10	$752.40
4	Each	1 *Cycle	721174	ELL-IND-GRV-90DEG 6 CST-STL 10	$0.00	$0.00	$8.00	$32.00
52	Each	1 *Cycle	720766	CPLR-IND-GRV 6 HW STL 77	$0.00	$0.00	$0.00	$0.00
1	Each	1 *Cycle	726303	ADAPT 4 FLGXGRV STL	$0.00	$0.00	$6.00	$6.00
1	Each	1 *Cycle	721531	RED-IND-GRV 6x4 ALUM	$0.00	$0.00	$9.00	$9.00
1	Each	1 *Cycle	721530	RED-IND-GRV 4x3 ALUM	$0.00	$0.00	$6.00	$6.00
2	Jnt	1 *Cycle	976910	PIPE-IND-GRV 6x10 ALUM 83	$0.00	$0.00	$8.00	$16.00
2	Jnt	1 *Cycle	976905	PIPE-IND-GRV 6x5 ALUM 83	$0.00	$0.00	$6.00	$12.00

Rental Sub Total: $2,996.40

Sub Total: $2,996.40

Rain for Rent Chandler

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P O Box 11070
Chandler, AZ 85248
Phone: 480-895-9225
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Rental Estimate

Estimate Number: 10-092-312895

OPTIONAL PRODUCTS

Optional Rental Items

Qty	Unit	Duration	Item	Description	Day	Week	*Cycle	Extension
1	Each	1 *Cycle	+811010	PUMP-TRASH DV100 TRLR/SKID	$0.00	$0.00	$975.00	$975.00

Rental Sub Total: $975.00

Optional Total: $975.00

P O Box 11070
Chandler, AZ 85248
Phone: 480-895-9225
Fax: 480-895-0345

Estimate Number: 10-092-312895

Additional Specifications

At this point in time we don't know what the water source is capable of producing as far as flow and volume.

Estimate is for 100 gpm assuming there is 20 lbs of pressure and 100 gpm available from water source.

Booster pump is available if water source can not produce enough pressure.

Jobwalk must be performed before estimate is accepted.

P O Box 11070
Chandler, AZ 85248
Phone: 480-895-9225
Fax: 480-895-0345

Estimate Number: 10-092-312895

Terms & Conditions

Additional Terms

1. A cycle is defined as 4 weeks. A week is defined as one third of a cycle and a day is one third of a week. Customers will be invoiced at the appropriate cycle, weekly or daily rate based on actual equipment usage except for filtration, pipe, hose and fittings which will be billed at the cycle rates only and will not be pro-rated.
2. The rental rate for pumps and equipment with hour meters are based on an 8 hour day or 48 hour running week. The rental rate will be multiplied by 1.5 for greater than 8 hours per day or 49-96 operating hours per week and multiplied by 2.0 for more than 16 hours per day or 96 operating hours per week. Customer will be invoiced for 24 hours per day if the hour meter has stopped functioning.
3. Overtime will be invoiced at 1.5 times the regular rate for work occurring outside of normally scheduled business hours and 2.0 times the regular rate for work occurring on company recognized holidays.
4. Customer shall pay for any changes to work scope including but not limited to schedule changes, material, labor, third party, permit, fee or service costs. It is the Customer's responsibility to cooperate in the timely processing, approval and payment of any charges within Rain For Rent's invoice terms.
5. Customer is responsible to determine the suitability of equipment for the application.
6. Delivery, Return, Installation and Removal costs are estimated. Customer will be invoiced for actual time. Transportation will be invoiced on a Portal to Portal basis.
7. Customer is responsible for flushing and cleaning tanks, roll off boxes, pipelines, pumps, filters and other Rain for Rent equipment prior to return.
8. Customer is responsible for equipment, repairs, maintenance and damage, excluding normal wear and tear. All returned equipment is subject to inspection by Rain for Rent personnel. Damages and accrued rent will be invoiced to Customer while equipment is out of service for repairs.
9. The Customer cannot alter the equipment without Rain For Rent's prior written approval.
10. Customer will provide "all risk" property insurance for rented equipment.
11. Customer will not allow any equipment to come in contact with any substance that will cause corrosion, damage or leakage.
12. The Customer assumes all risks of loss due to operation and use of the equipment.
13. Customer is responsible to obtain any permits, licenses, certificates, bonds and give all notices required by law.
14. The rental period begins the day the equipment is delivered and continues until returned to Rain For Rent's facility unless written confirmation of the release is provided to the Customer before that time.
15. Rental equipment must be returned to the renting Rain for Rent branch unless agreed to in writing before the rental period begins.
16. All material that comes in contact with Rain For Rent equipment including media is the responsibility of Customer as generator. Rain For Rent shall not be responsible for any fines or sanctions as a result of Customer's use of the equipment.
17. The equipment is sold "AS IS,WHERE IS" in its present condition. Seller makes no warranties, expressed or implied of any kind whatsoever with respect to the equipment. Buyer agrees that buyer has purchased the equipment based on his judgement and evaluation, without reliance upon any statements of representations of seller, and that seller is not responsible for any defects in its operation or for any repairs, parts or services, unless otherwise noted.
18. De-watering, Roll-off, Vacuum boxes and similar equipment are not liquid tight. Rentee accepts full responsibility for all losses, damages and costs caused by or arising out of spills, leakage or discharge from this equipment.
19. Customer will use the equipment in a careful and proper manner and in accordance with safety rules, industry standards, manufacturer's specifications, recommendations, regulations and applicable laws
20. Customer shall be responsible for environmental fees covering waste fluid, fuel, filter and other disposal costs.
21. A Fuel Surcharge will be calculated and invoiced based on the diesel fuel price as published by the Department of Energy on http://tonto.eia.doe.gov/oog/info/wohdp/diesel.asp
22. Customer shall pay Rain For Rent additional expenses caused by site, soil or underground conditions, including, but not limited to, rock formations, environmental conditions, regulations or restrictions, hard pan, boulders, cesspools, gas lines, water lines, drain pipes, underground electrical conduits or other above ground or underground obstructions.
23. Customer shall be responsible for acquiring and paying for, if necessary, all public and private property easements required by the project.
24. The estimated labor component of this quote is based on non-prevailing wage rates. If prevailing wage laws are applicable, Customer must notify Rain For Rent in writing before Rain For Rent estimate completed. If Rain For Rent was not properly notified, Customer shall promptly pay any change orders that adjust wages to prevailing wage rates. Customer is responsible for providing applicable prevailing wage rates to Rain for Rent. Rain For Rent will provide certified payrolls on a bi-weekly basis if notified in writing 10 days before the start of the project.
25. Customer is prohibited from deducting retention from Rain For Rent invoices and charging Rain for Rent liquidated damages.
26. Customer is responsible for all routine maintenance including fuel, fluids, lubrication and filters every 150 hours on engine driven equipment. Rain For Rent will charge Customer for servicing any equipment that is on rent or returned that has not been serviced in 150 hours. Rain For Rent can provide field service upon request for an additional service charge. Rain For Rent must be notified 2 business days in advance to schedule required field service.
27. This estimate excludes any additional costs to Rain For Rent associated with Owner Controlled Insurance (OCIP) or WRAP insurance programs that will be added to Rain For Rent's prices.
28. Customer is responsible to provide freeze protection for all equipment on site.
29. Customer will be responsible for security, traffic control and road crossings. Traffic control shall meet all applicable Federal, State, and Municipal laws and regulations to assure a safe work environment.

30. Cold Weather Packages for tanks consist of up to 4 tank heaters and a submersible pump which is designed for use in a non-combustible or corrosive environment.

31. Tank heaters are operated on 120 volts, 12.5 amps each or 50 amps total. The submersible pump operates at 120 volts, 10 amps.

32. Customer is responsible for electrical connections and compliance with applicable permits, regulations and code requirements.

33. Tank Cold Weather Packages are not to be used in combustible or corrosive environments.

34. Tank Cold Weather Packages are a preventative measure that may keep fluids inside the tank from freezing. RFR will not guarantee fluids from freezing and any resulting damages.

Custom Estimate Developed Especially for:

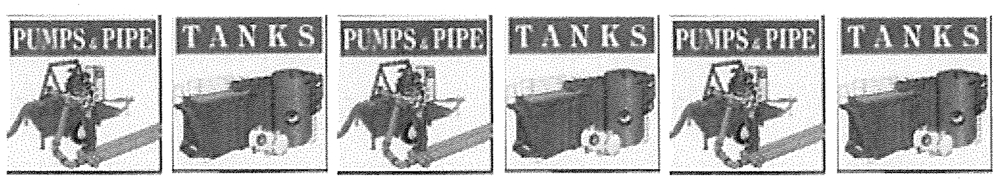
Jason Hilker
Erm West Inc
1777 Betelho Dr Ste 260
Walnut Creek, CA 94596
Phone: 480-998-2401

Prepared on 1/4/2010 by:

Rain for Rent

David Jewett
Cell: (602)725-7839
P O Box 11070
Chandler, AZ 85248
Phone: 480-895-9225
Fax: 480-895-0345

www.rainforrent.com



Rain for Rent Chandler

Rental Estimate

www.rainforrent.com

P O Box 11070
Chandler, AZ 85248
Phone: 480-895-9225
Fax: 480-895-0345

Estimate Number: 10-092-313469
Prepared By: David Jewett

Customer: Erm West Inc

Customer ID: 920545
Address: 1777 Betelho Dr Ste 260
City/State: Walnut Creek, CA 94596
Contact: Jason Hilker
Office: 480-998-2401
Fax:

Job Description:
Fill poly tanks with clean water.

Location:
Litchfield rd and Goodyear rd
Litchfield Park, Az 85340

Rental Sub Total: $1,999.00

Sub Total: $1,999.00

*The Terms and Conditions of the Rain For Rent Rental and Acute Hazardous Waste Agreements, Credit Application, Invoice and this estimate contain the complete and final agreement between Rain For Rent and Customer and no other agreement in any way modifying or adding to any of said Terms and Conditions will be binding upon Rain For Rent unless made In writing and signed by a Rain For Rent Corporate Officer.
*Payment terms are net 30 days from invoice date. A 1.5%month late charge will be made on any past due invoices.
*Estimate is valid for 30 days and is subject to credit approval.
*Availability subject to change without notice.
*Estimates are based on Customer supplied information and are subject to change based on actual requirements and usage.

Est. Delivery Hauling	$822.50
Est. Pick-up Hauling	$467.50
Est. Install Labor	$282.00
Est. Removal Labor	$141.00
Est. Services	$0.00
Est. Fuel Surcharge	$0.00

(Does Not Include Sales Tax)

Estimate Total: $3,712.00

Date Prepared: 1/4/2010

Valid Until: 2/03/2010

Customer

Date

If customer requires a PO# to process and submit payment, it must be supplied to Rain for Rent at the time of acceptance of this estimate.
Please insert Purchase Order number here: ____________________

By signing this estimate, customer represents that customer has read and agreed to all terms of this estimate, including those on Terms & Conditions page and those on the Additional Specifications page (if applicable).

Rain
for
Rent Chandler

Rental Estimate

www.rainforrent.com

P O Box 11070
Chandler, AZ 85248
Phone: 480-895-9225
Fax: 480-895-0345

Estimate Number: 10-092-313469

Application: Poly Tank Fill Materials: Clean Water

*Rain for Rent Cycle = 28 Days.
This estimate has not been flagged as PREVAILING WAGE.

Rental Items

Qty	Unit	Duration	Item	Description	Day	Week	*Cycle	Extension
2	Each	28 Day	+660506	TANK-POLY 4900 GAL	$17.25	$0.00	$0.00	$966.00
1	Each	28 Day	+670501	SPILLGUARD-12'X16'X1'	$12.75	$0.00	$0.00	$357.00
1	Each	28 Day	+670504	SPILLGUARD-12'X50'X1'	$23.25	$0.00	$0.00	$651.00
2	Each	2 *Cycle	MRC	3"MIPTx4" VIC	$0.00	$0.00	$6.00	$24.00
2	Each	1 *Cycle	720764	CPLR-IND-GRV 4 HW STL 77	$0.00	$0.00	$0.50	$1.00

Rental Sub Total: $1,999.00

Sub Total: $1,999.00

P O Box 11070
Chandler, AZ 85248
Phone: 480-895-9225
Fax: 480-895-0345

Estimate Number: 10-092-313469

Additional Specifications

Customer is responsible for chlorination and Bac. T testing of the tanks.

Customer has noted that clean water will be in the poly tanks.

P O Box 11070
Chandler, AZ 85248
Phone: 480-895-9225
Fax: 480-895-0345

Estimate Number: 10-092-313469

Terms & Conditions

Additional Terms

1. A cycle is defined as 4 weeks. A week is defined as one third of a cycle and a day is one third of a week. Customers will be invoiced at the appropriate cycle, weekly or daily rate based on actual equipment usage except for filtration, pipe, hose and fittings which will be billed at the cycle rates only and will not be pro-rated.
2. The rental rate for pumps and equipment with hour meters are based on an 8 hour day or 48 hour running week. The rental rate will be multiplied by 1.5 for greater than 8 hours per day or 49-96 operating hours per week and multiplied by 2.0 for more than 16 hours per day or 96 operating hours per week. Customer will be invoiced for 24 hours per day if the hour meter has stopped functioning.
3. Overtime will be invoiced at 1.5 times the regular rate for work occurring outside of normally scheduled business hours and 2.0 times the regular rate for work occurring on company recognized holidays.
4. Customer shall pay for any changes to work scope including but not limited to schedule changes, material, labor, third party, permit, fee or service costs. It is the Customer's responsibility to cooperate in the timely processing, approval and payment of any charges within Rain For Rent's invoice terms.
5. Customer is responsible to determine the suitability of equipment for the application.
6. Delivery, Return, Installation and Removal costs are estimated. Customer will be invoiced for actual time. Transportation will be invoiced on a Portal to Portal basis.
7. Customer is responsible for flushing and cleaning tanks, roll off boxes, pipelines, pumps, filters and other Rain for Rent equipment prior to return.
8. Customer is responsible for equipment, repairs, maintenance and damage, excluding normal wear and tear. All returned equipment is subject to inspection by Rain for Rent personnel. Damages and accrued rent will be invoiced to Customer while equipment is out of service for repairs.
9. The Customer cannot alter the equipment without Rain For Rent's prior written approval.
10. Customer will provide "all risk" property insurance for rented equipment.
11. Customer will not allow any equipment to come in contact with any substance that will cause corrosion, damage or leakage.
12. The Customer assumes all risks of loss due to operation and use of the equipment.
13. Customer is responsible to obtain any permits, licenses, certificates, bonds and give all notices required by law.
14. The rental period begins the day the equipment is delivered and continues until returned to Rain For Rent's facility unless written confirmation of the release is provided to the Customer before that time.
15. Rental equipment must be returned to the renting Rain for Rent branch unless agreed to in writing before the rental period begins.
16. All material that comes in contact with Rain For Rent equipment including media is the responsibility of Customer as generator. Rain For Rent shall not be responsible for any fines or sanctions as a result of Customer's use of the equipment.
17. The equipment is sold "AS IS,WHERE IS" in its present condition. Seller makes no warranties, expressed or implied of any kind whatsoever with respect to the equipment. Buyer agrees that buyer has purchased the equipment based on his judgement and evaluation, without reliance upon any statements of representations of seller, and that seller is not responsible for any defects in its operation or for any repairs, parts or services, unless otherwise noted.
18. De-watering, Roll-off, Vacuum boxes and similar equipment are not liquid tight. Rentee accepts full responsibility for all losses, damages and costs caused by or arising out of spills, leakage or discharge from this equipment.
19. Customer will use the equipment in a careful and proper manner and in accordance with safety rules, industry standards, manufacturer's specifications, recommendations, regulations and applicable laws
20. Customer shall be responsible for environmental fees covering waste fluid, fuel, filter and other disposal costs.
21. A Fuel Surcharge will be calculated and invoiced based on the diesel fuel price as published by the Department of Energy on http://tonto.eia.doe.gov/oog/info/wohdp/diesel.asp
22. Customer shall pay Rain For Rent additional expenses caused by site, soil or underground conditions, including, but not limited to, rock formations, environmental conditions, regulations or restrictions, hard pan, boulders, cesspools, gas lines, water lines, drain pipes, underground electrical conduits or other above ground or underground obstructions.
23. Customer shall be responsible for acquiring and paying for, if necessary, all public and private property easements required by the project.
24. The estimated labor component of this quote is based on non-prevailing wage rates. If prevailing wage laws are applicable, Customer must notify Rain For Rent in writing before Rain For Rent estimate completed. If Rain For Rent was not properly notified, Customer shall promptly pay any change orders that adjust wages to prevailing wage rates. Customer is responsible for providing applicable prevailing wage rates to Rain for Rent. Rain For Rent will provide certified payrolls on a bi-weekly basis if notified in writing 10 days before the start of the project.
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34. Tank Cold Weather Packages are a preventative measure that may keep fluids inside the tank from freezing. RFR will not guarantee fluids from freezing and any resulting damages.

Job Specific Terms

35. Customer shall hold harmless, indemnify and defend Rain For Rent from any claims whatsoever, arising from or related to (A) any pollution, contamination, environmental impairment and/or similar condition directly or indirectly caused by or resulting in whole or in part from Customer's use of any Equipment or (B) any environmental statutory or regulatory compliance requirements applicable to any equipment (or any use thereof) and required under any and all foreign or domestic federal, state or local laws,ordinances, regulations, codes, or requirements of any governmental authorities which regulate or impose standards of liability or conduct concerning air, water, soils, wetlands and watercourses, solid waste, hazardous waste and/or materials, worker and community right-to-know, noise, resource protection, health protection and similar environmental, health, safety, and land use concerns as may now or at any time hereafter be in effect. This indemnification shall survive the termination of the agreement.
36. Rentee acknowledges that Units may have contained Hazardous Waste in the past. Rentee may, at its sole option and expense, test a Unit prior to taking delivery of it from Rentor. In the event that Hazardous Waste is detected in a Unit prior to Rentee taking delivery thereof, Rentee shall have the option to terminate the renting of such Unit. IN THE EVENT THAT RENTEE ELECTS NOT TO (I) TERMINATE THE RENTING OF ANY SUCH UNIT OR (II) TEST ANY UNIT, RENTEE SHALL THEREBY WAIVE ANY RIGHT TO OBJECT TO THE PRESENCE OF HAZARDOUS WASTE IN SUCH UNIT OR MAKE ANY CLAIM AGAINST RENTOR IN RESPECT THEREOF.

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

4625 East Cotton Center Blvd. Ste 189
Phoenix, AZ 85040
Phone: (602) 437-3340
Fax: (602) 454-9303
www.testamericainc.com

PRICE QUOTE FOR LABORATORY SERVICES

Client:	Haley & Aldrich - Tucson	**Phone:**	(520) 289-8600
Client Contact:	Laura Davis	**Fax:**	(520) 289-8675
Client Address:	600 South Meyer Avenue, Suite 100 - Tucson, AZ 85701-2554	**Date:**	November 16, 2011
PO#/Contract#:	None	**Quote Expires:**	November 15, 2012
Project/Bid Name:	Phoenix-Goodyear Airport-North	**Expected Start Date:**	November 16, 2011

The Project Description Phoenix-Goodyear Airport-North, MUST be present on the chain of custody to receive the following discounted prices

Method	Description	Matrix	TAT	Quantity	Unit Price	Subtotal	Rush Charge	Total
EPA 8260B	Volatile Organics (EPA 8260B)	Soil	48 Hour	1	$60.00	$60.00	$45.00	$105.00
Bid Subtotal For Soil Samples:					**$60.00**	**$60.00**	**$45.00**	**$105.00**
EPA 8260B	Volatile Organics (EPA 8260B)	Water	48 Hour	1	$60.00	$60.00	$45.00	$105.00
Bid Subtotal For Water Samples:					**$60.00**	**$60.00**	**$45.00**	**$105.00**
Bid Total:								**$210.00**

LINE ITEMS

Description	ItemType	Quantity	Price	Rate	ItemTotal
Methanol Kit	Standard	2	2.50		5.00
				Total	**$5.00**

* Each invoice is subject to an Environmental Management Fee.
** TestAmerica's minimum charge for a group of samples received and logged in together at the laboratory is $100. Groups of samples received that require services totaling less than $100 will be charged a $100 minimum transaction fee for the sample group.

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Adjusted Bid Total:

Bid Total:	$210.00
Line Item Total:	$5.00
Bid Total:	**$215.00**

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Sincerely,

TestAmerica Laboratories, Inc.

Elizabeth C Baker

Elizabeth Baker

Wednesday, November 16, 2011 2:37:33PM

4625 East Cotton Center Blvd. Ste 189
Phoenix, AZ 85040
Phone: (602) 437-3340
Fax: (602) 454-9303
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TestAmerica Terms and Conditions of Sale

Where a purchaser (Client) places an order for laboratory, consulting or sampling services from TestAmerica Laboratories, Inc., a Delaware corporation (referred to as "TestAmerica"), TestAmerica shall provide the ordered services pursuant to these Terms and Conditions, and the related Quotation or Price Schedule, or as agreed in a negotiated contract. In the absence of a written agreement to the contrary, the Order constitutes an acceptance by the Client of TestAmerica's offer to do business under these Terms and Conditions, and an agreement to be bound by these Terms and Conditions. No contrary or additional terms and conditions expressed in a Client's document shall be deemed to become a part of the contract created upon acceptance of these Terms and Conditions, unless accepted by TestAmerica in writing.

1. ORDERS AND RECEIPT OF SAMPLES

1.1 The Client may place the Order (i.e., specify a Scope of Work) either by submitting a purchase order to TestAmerica in writing or by telephone subsequently confirmed in writing, or by negotiated contract. Whichever option the Client selects for placing the Order, the Order shall not be valid unless it contains sufficient specification to enable TestAmerica to carry out the Client's requirements. In particular, samples must be accompanied by: a) adequate instruction on type of analysis requested, and b) complete written disclosure of the known or suspected presence of any hazardous substances, as defined by applicable federal or state law. Where any samples which were not accompanied by the required disclosure, cause interruptions in the lab's ability to process work due to contamination of instruments or work areas, the Client will be responsible for the costs of clean up and recovery.

1.2 The Client shall provide one week's advance notice of the sample delivery schedule, or any changes to the schedule, whenever possible. Upon timely delivery of samples, TestAmerica will use its best efforts to meet mutually agreed turnaround times. All turnaround times will be calculated from the point in time when TestAmerica has determined that it can proceed with defined work following receipt, inspection of samples, and resolution of any discrepancies in Chain-of-Custody forms and project guidance regarding work to be done (Sample Delivery Acceptance). In the event of any changes in the sample delivery schedule by the Client, prior to Sample Delivery Acceptance, TestAmerica reserves the right to modify its turnaround time commitment, to change the date upon which TestAmerica will accept samples, or refuse Sample Delivery Acceptance for the affected samples.

1.3 TestAmerica reserves the right, exercisable at any time, to refuse or revoke Sample Delivery Acceptance for any sample which in the sole judgment of TestAmerica: a) is of unsuitable volume; b) may pose a risk or become unsuitable for handling, transport, or processing for any health, safety, environmental or other reason, whether or not due to the presence in the sample of any hazardous substance and whether or not such presence has been disclosed to TestAmerica by the Client; or c) holding times cannot be met, due to passage of more than 48 hours from the time of sampling or 1/2 the holding time for the requested test, whichever is less.

1.4 Prior to Sample Delivery Acceptance, the entire risk of loss or damage to samples remains with the Client, except where TestAmerica provides courier services. In no event will TestAmerica have any responsibility or liability for the action or inaction of any carrier shipping or delivering any sample to or from TestAmerica's premises. Client is responsible to assure that any sample containing any hazardous substance which is to be delivered to TestAmerica's premises will be packaged, labeled, transported and delivered properly and in accordance with applicable laws.

2. PAYMENT TERMS

2.1 Services performed by TestAmerica will be in accordance with prices quoted and later confirmed in writing or as stated in the Price Schedule. Where reports are issued in or delivered to a state which assesses sales tax on TestAmerica's services, applicable sales taxes will be added to the invoice as required by law, unless an appropriate sales tax exemption form is on file with TestAmerica. Where requested services on a group of samples received and logged in together at the laboratory total less than $100, there will be a minimum transaction charge of $100 for the sample group, or as shown on any related quote from TestAmerica. An Environmental Management Fee of 5% of the invoice value will also be applied, at TestAmerica's discretion.

2.2 Invoices may be submitted to Client upon completion of any sample delivery group. Billing corrections must be requested within 30 days of invoice date. Payment in advance is required for all Clients except those whose credit has been
established with TestAmerica. For Clients with approved credit, payment terms are net 30 days days of invoice date. Payment in advance is required for all Clients except those whose credit has been established with TestAmerica. For Clients with approved credit, payment terms are net 30 days from the date of invoice by TestAmerica. All overdue payments are subject to an additional interest and service charge of one and one-half percent (1.5%) (or the maximum rate permissible by law, whichever is lesser) per month or portion thereof from the due date until the date of payment. All fees are charged or billed directly to the Client. The billing of a third party will not be accepted without a statement, signed by the third party that acknowledges and accepts payment responsibility.

2.3 TestAmerica may suspend work and withhold delivery of data under this order at any time in the event Client fails to make timely payment of its invoices. Client shall be responsible for all costs and expenses of collection including reasonable attorney's fees. TestAmerica reserves the right to refuse to proceed with work at any time based upon an unfavorable Client credit report.

3. CHANGE ORDERS, TERMINATION

3.1 Changes to the Scope of Work, price, or result delivery date may be initiated by TestAmerica after Sample Delivery Acceptance due to any condition which conflicts with analytical, QA or other protocols warranted in these Terms and Conditions. TestAmerica will not proceed with such changes until an agreement with the Client is reached on the amount of any cost, schedule change or technical change to the Scope of Work, and such agreement is documented in writing.

3.2 Changes to the Scope of Work, including but not limited to increasing or decreasing the work, changing test and analysis specification, or acceleration in the performance of the work may be initiated by the Client after sample delivery acceptance. Such a change will be documented in writing and may result in a change in cost and turnaround time commitment. TestAmerica's acceptance of such changes is contingent upon technical feasibility and operational capacity.

3.3 Suspension or termination of all or any part of the work may be initiated by the Client. TestAmerica will be compensated consistent with Section 2 of these Terms and Conditions. TestAmerica will complete all work in progress and be paid in full for all work completed.

4. WARRANTIES AND LIABILITY

4.1 Where applicable, TestAmerica will use analytical methodologies which are in substantial conformity with published test methods. TestAmerica has implemented these methods in its Laboratory Quality Manuals and referenced Standard Operating Procedures and where the nature or composition of the sample requires it, TestAmerica reserves the right to deviate from these methodologies as necessary or appropriate, based on the reasonable judgment of TestAmerica, which deviations, if any, will be made on a basis consistent with recognized standards of the industry and/or TestAmerica's Laboratory Quality Manuals. Client may request that TestAmerica perform according to a mutually agreed Quality Assurance Project Plan (QAPP). In the event that samples arrive prior to agreement on a QAPP, TestAmerica will proceed with analyses under its standard Quality Manuals then in effect, and TestAmerica will not be responsible for any resampling or other charges if work must be repeated to comply with a subsequently finalized QAPP.

4.2 TestAmerica shall start preparation and/or analysis within holding times provided that Sample Delivery Acceptance occurs within 48 hours of sampling or 1/2 of the holding time for the test, whichever is less. Where resolution of inconsistencies leading to Sample Delivery Acceptance does not occur within this period, TestAmerica will use its best efforts to meet holding times and will proceed with the work provided that, in TestAmerica's judgment, the chain-of-custody or definition of the Scope of Work provide sufficient guidance. Reanalysis of samples to comply with TestAmerica's Quality Manuals will be deemed to have met holding times provided the initial analysis was performed within the applicable holding time. Where reanalysis demonstrates that sample matrix interference is the cause of failure to meet any Quality Manual requirements, the warranty will be deemed to have been met.

4.3 TestAmerica warrants that it possesses and maintains all licenses and certifications which are required to perform services under these Terms and Conditions provided that such requirements are specified in writing to TestAmerica prior to Sample Delivery Acceptance. TestAmerica will notify the Client in writing of any decertification or revocation of any license, or notice of either, which affects work in progress.

4.4 The warranty obligations set forth in Sections 4.1, 4.2 and 4.3 are the sole and exclusive warranties given by TestAmerica in connection with any services performed by TestAmerica or any Results generated from such services, and TestAmerica gives and makes NO OTHER REPRESENTATION OR WARRANTY OF ANY KIND,

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EXPRESS OR IMPLIED. No representative of TestAmerica is authorized to give or make any other representation or warranty or modify this warranty in any way.

4.5 Client's sole and exclusive remedy for the breach of warranty in connection with any services performed by TestAmerica, will be limited to repeating any services performed, contingent on the Client's providing, at the request of TestAmerica and at the Client's expense, additional sample(s) if necessary. Any reanalysis requested by the Client generating Results consistent with the original Results will be at the Client's expense. If resampling is necessary, TestAmerica's liability for resampling costs will be limited to actual cost or one hundred and fifty dollars ($150) per sample, whichever is less.

4.6 TestAmerica's liability for any and all causes of action arising hereunder, whether based in contract, tort, warranty, negligence or otherwise, shall be limited to the lesser amount of compensation for the services performed or $100,000. All claims, including those for negligence, shall be deemed waived unless suit thereon is filed within one year after TestAmerica's completion of the services. Under no circumstances, whether arising in contract, tort (including negligence), or otherwise, shall TestAmerica be responsible for loss of use, loss of profits, or for any special, indirect, incidental or consequential damages occasioned by the services performed or by application or use of the reports prepared.

4.7 In no event shall TestAmerica have any responsibility or liability to the Client for any failure or delay in performance by TestAmerica which results, directly or indirectly, in whole or in part, from any cause or circumstance beyond the reasonable control of TestAmerica. Such causes and circumstances shall include, but not be limited to, acts of God, acts of Client, acts or orders of any governmental authority, strikes or other labor disputes, natural disasters, accidents, wars, civil disturbances, equipment breakdown, matrix interference or unknown highly contaminated samples that impact instrument operation, unavailability of supplies from usual suppliers, difficulties or delays in transportation, mail or delivery services, or any other cause beyond TestAmerica's reasonable control.

5. RESULTS, WORK PRODUCT

5.1 Data or information provided to TestAmerica or generated by services performed under this agreement shall only become the property of the Client upon receipt in full by TestAmerica of payment for the whole Order. Ownership of any analytical method, QA/QC protocols, software programs or equipment developed by TestAmerica for performance of work will be retained by TestAmerica, and Client shall not disclose such information to any third party.

5.2 Data and sample materials provided by Client or at Client’s request, and the result obtained by TestAmerica shall be held in confidence (unless such information is generally available to the public or is in the public domain or Client has failed to pay TestAmerica for all services rendered or is otherwise in breach of these Terms and Conditions), subject to any disclosure required by law or legal process.

5.3 Should the Results delivered by TestAmerica be used by the Client or Client's client, even though subsequently determined not to meet the warranties described in these Terms and Conditions, then the compensation will be adjusted based upon mutual agreement. In no case shall the Client unreasonably withhold TestAmerica's right to independently defend its data.

5.4 TestAmerica reserves the right to perform the services at any laboratory in the TestAmerica network, unless the Client has specified a particular location for the work. In addition, TestAmerica reserves the right to subcontract services ordered by the Client to another laboratory or laboratories, if, in TestAmerica's sole judgment, it is reasonably necessary, appropriate or advisable to do so. TestAmerica will in no way be liable for any subcontracted services (outside the TestAmerica network) except for work performed at laboratories which have been audited and approved by TestAmerica.

5.5 TestAmerica shall dispose of the Client's samples 30 days after the analytical report is issued, unless instructed to store them for an alternate period of time or to return such samples to the Client, in a manner consistent with U.S. Environmental Protection Agency regulations or other applicable federal, state or local requirements. Air samples in Summa canisters will be retained for 5 days after analysis and data review. Longer storage periods may be requested and may be accommodated as space allows for an additional charge. Any samples for projects that are canceled or not accepted, or for which return was requested, will be returned to the Client at his own expense. TestAmerica reserves the right to return to the Client any sample or unused portion of a sample that is not within TestAmerica's permitted capability or the capabilities of TestAmerica's designated waste disposal vendor(s). ALL DIOXIN, MIXED WASTE, AND RADIOACTIVE SAMPLES WILL BE RETURNED TO THE CLIENT, unless prior arrangements for disposal are made.

5.6 Unless a different time period is agreed to in any order under these Terms and Conditions, TestAmerica agrees to retain all records for five (5) years.

5.7 In the event that TestAmerica is required to respond to legal process related to services for Client, Client agrees to reimburse TestAmerica for hourly charges for personnel involved in the response and attorney fees reasonably incurred in obtaining advice concerning the response, preparation to testify, and appearances related to the legal process, travel and all reasonable expenses associated with the litigation.

6. INSURANCE

6.1 TestAmerica shall maintain in force during the performance of services under these Terms and Conditions, Workers' Compensation and Employer's Liability Insurance in accordance with the laws of the states having jurisdiction over TestAmerica's employees who are engaged in the performance of the work. TestAmerica shall also maintain during such period, Comprehensive General and Contractual Liability (limit of $1,000,000 per occurrence/ $2,000,000aggregate), Comprehensive Automobile Liability, owned and hired, ($1,000,000 combined single limit), and Professional/Pollution Liability Insurance (limit of $5,000,000 per occurrence/aggregate).

7. AUDIT

7.1 Upon prior notice to TestAmerica, the Client may audit and inspect TestAmerica's records and accounts covering reimbursable costs related to work done for the Client, for a period of two (2) years after completion of the work. The purpose of any such audit shall be only for verification of such costs, and TestAmerica shall not be required to provide access to cost records where prices are expressed as fixed fees or published unit prices.

8. MISCELLANEOUS PROVISIONS

8.1 These Terms and Conditions, together with any additions or revisions which may be agreed to in writing by TestAmerica, embody the whole agreement of the parties and provide the only remedies available. There are no promises, terms, conditions, understandings, obligations or agreements other than those contained herein, and these Terms and Conditions shall supersede all previous communications, representations, or agreements, either verbal or written, between the Client and TestAmerica. These Terms and Conditions, and any transactions or agreements to which they apply, shall be governed both as to interpretation and performance by the laws of the state where TestAmerica's services are performed.

8.2 The invalidity or unenforceability, in whole or in part of any provision, term or condition hereof shall not affect in any way the validity or enforceability of the remainder to these Terms and Conditions, the intent of the parties being that the provisions be severable. The section headings of these Terms and Conditions are intended solely for convenient reference and shall not define, limit or affect in any way these Terms and Conditions or their interpretations. No waiver by either party of any provision, term or condition hereof or of any obligation of the other party hereunder shall constitute a waiver of any subsequent breach or other obligation.

8.3 The obligations, liabilities, and remedies of the parties, as provided herein, are exclusive and in lieu of any others available at law or in equity. Indemnifications, releases from liability and limitations of liability shall apply, notwithstanding the fault, negligence or strict liability of the party to be indemnified, released, or whose liability is limited, except to the extent of sole negligence or willful misconduct.

TestAmerica
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TURNAROUND TIME PRICING

VOLATILE ORGANICS (EPA 8260B) in SOIL

Same Day Rush	1 Day Rush	2 Day Rush	3 Day Rush	5 Day Rush	Standard TAT
$180.00	$120.00	$105.00	$90.00	$60.00	$60.00

VOLATILE ORGANICS (EPA 8260B) in WATER

Same Day Rush	1 Day Rush	2 Day Rush	3 Day Rush	5 Day Rush	Standard TAT
$180.00	$120.00	$105.00	$90.00	$60.00	$60.00

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ANALYTICAL METHOD INFORMATION

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VOLATILE ORGANICS (EPA 8260B) in SOIL (EPA 8260B)

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	BlankSpike/LCS %R	BlankSpike/LCS RPD
Acetone	400	1000 ug/kg			16 - 149	40	20 - 150	50
Benzene	9.8	50 ug/kg			55 - 123	20	70 - 130	33
Bromobenzene	11	250 ug/kg			59 - 129	23	70 - 130	28
Bromochloromethane	15	250 ug/kg			56 - 129	31	70 - 130	37
Bromodichloromethane	14	100 ug/kg			60 - 124	24	70 - 130	34
Bromoform	24	250 ug/kg			51 - 109	27	58 - 108	35
Bromomethane	30	250 ug/kg			39 - 123	35	65 - 116	33
2-Butanone (MEK)	130	1000 ug/kg			35 - 126	39	33 - 143	53
n-Butylbenzene	9.3	250 ug/kg			41 - 150	28	70 - 130	27
sec-Butylbenzene	6.7	250 ug/kg			40 - 146	30	70 - 130	28
tert-Butylbenzene	7.9	250 ug/kg			49 - 138	29	70 - 130	27
Carbon disulfide	19	500 ug/kg			20 - 127	32	53 - 119	35
Carbon tetrachloride	12	250 ug/kg			45 - 140	23	68 - 133	32
Chlorobenzene	8.6	50 ug/kg			61 - 123	21	70 - 130	29
Chloroethane	15	250 ug/kg			44 - 125	32	67 - 120	32
Chloroform	7.7	100 ug/kg			57 - 131	27	70 - 130	33
Chloromethane	21	250 ug/kg			28 - 119	40	44 - 121	36
2-Chlorotoluene	7.6	250 ug/kg			52 - 136	23	70 - 130	27
4-Chlorotoluene	8.6	250 ug/kg			56 - 136	21	70 - 130	28
Dibromochloromethane	8.8	100 ug/kg			59 - 117	23	70 - 130	35
1,2-Dibromo-3-chloropropane	74	250 ug/kg			44 - 121	34	55 - 116	42
1,2-Dibromoethane (EDB)	11	25 ug/kg			62 - 119	24	70 - 130	36
Dibromomethane	17	100 ug/kg			57 - 124	26	70 - 130	37
1,2-Dichlorobenzene	7.4	100 ug/kg			54 - 130	23	70 - 130	28
1,3-Dichlorobenzene	8.1	100 ug/kg			53 - 132	23	70 - 130	27
1,4-Dichlorobenzene	7.4	100 ug/kg			55 - 132	22	70 - 130	27
Dichlorodifluoromethane	18	250 ug/kg			10 - 96	25	15 - 117	39
1,1-Dichloroethane	9.6	100 ug/kg			57 - 132	26	70 - 130	33
1,2-Dichloroethane	19	50 ug/kg			52 - 138	30	71 - 139	37
1,1-Dichloroethene	14	250 ug/kg			50 - 131	32	70 - 130	31
cis-1,2-Dichloroethene	11	100 ug/kg			58 - 118	24	70 - 130	35
trans-1,2-Dichloroethene	9.6	100 ug/kg			57 - 128	27	70 - 130	31
1,2-Dichloropropane	11	100 ug/kg			61 - 124	21	70 - 130	31
1,3-Dichloropropane	11	100 ug/kg			63 - 116	21	70 - 130	32
2,2-Dichloropropane	17	100 ug/kg			50 - 123	26	65 - 122	31
1,1-Dichloropropene	11	100 ug/kg			52 - 129	21	70 - 130	30
cis-1,3-Dichloropropene	14	100 ug/kg			50 - 139	25	70 - 130	35
trans-1,3-Dichloropropene	9.6	100 ug/kg			45 - 132	26	70 - 130	37
Ethylbenzene	8.4	100 ug/kg			54 - 133	27	70 - 130	28
Hexachlorobutadiene	11	250 ug/kg			10 - 150	34	70 - 130	31
2-Hexanone	57	1000 ug/kg			30 - 115	36	31 - 136	48
Iodomethane	12	250 ug/kg			42 - 125	30	68 - 117	32
Isopropylbenzene	11	100 ug/kg			60 - 144	29	70 - 130	27
p-Isopropyltoluene	8.4	100 ug/kg			44 - 140	30	70 - 130	30
Methylene Chloride	50	500 ug/kg			52 - 132	30	70 - 130	38
4-Methyl-2-pentanone (MIBK)	54	1000 ug/kg			50 - 124	29	59 - 124	51
Methyl-tert-butyl Ether (MTBE)	16	250 ug/kg			56 - 128	32	69 - 132	46
Naphthalene	11	250 ug/kg			35 - 128	30	70 - 130	38

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VOLATILE ORGANICS (EPA 8260B) in SOIL (EPA 8260B)

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	BlankSpike/LCS %R	BlankSpike/LCS RPD
n-Propylbenzene	11	100 ug/kg			50 - 148	29	70 - 130	29
Styrene	5.3	100 ug/kg			45 - 122	22	70 - 130	30
1,1,1,2-Tetrachloroethane	12	250 ug/kg			63 - 120	21	70 - 130	32
1,1,2,2-Tetrachloroethane	13	100 ug/kg			44 - 139	40	63 - 129	38
Tetrachloroethene	10	100 ug/kg			47 - 138	31	70 - 130	26
Toluene	11	100 ug/kg			59 - 129	20	70 - 130	31
1,2,3-Trichlorobenzene	13	250 ug/kg			32 - 137	30	70 - 130	35
1,2,4-Trichlorobenzene	11	250 ug/kg			28 - 139	26	66 - 124	31
1,1,1-Trichloroethane	13	100 ug/kg			53 - 133	25	70 - 130	32
1,1,2-Trichloroethane	23	100 ug/kg			57 - 118	29	70 - 130	39
Trichloroethene	8.2	100 ug/kg			56 - 136	26	70 - 130	29
Trichlorofluoromethane	9.5	250 ug/kg			41 - 148	27	72 - 143	37
1,2,3-Trichloropropane	12	500 ug/kg			56 - 131	24	64 - 125	39
1,2,4-Trimethylbenzene	10	100 ug/kg			28 - 139	26	66 - 124	31
1,3,5-Trimethylbenzene	6.9	100 ug/kg			48 - 146	35	70 - 130	27
Vinyl Acetate	31	1200 ug/kg			10 - 150	40	46 - 150	50
Vinyl chloride	8.0	250 ug/kg			12 - 97	40	10 - 118	65
Xylenes, Total	21	150 ug/kg			57 - 122	22	70 - 130	32
Sur: Dibromofluoromethane			57 - 129					
Sur: Toluene-d8			59 - 134					
Sur: 4-Bromofluorobenzene			56 - 127					
*o-Xylene		NA				28		14
*m,p-Xylenes		NA				27		16

* - Analyte not a part of normal reporting list. Special request only.

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VOLATILE ORGANICS (EPA 8260B) in WATER (EPA 8260B)

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	BlankSpike/LCS %R	BlankSpike/LCS RPD
Acetone	7.3	20 ug/l			10 - 150	35	30 - 150	35
Benzene	0.12	1.0 ug/l			70 - 130	20	70 - 130	20
Bromobenzene	0.14	1.0 ug/l			70 - 130	20	70 - 130	20
Bromochloromethane	0.27	1.0 ug/l			70 - 130	20	70 - 130	20
Bromodichloromethane	0.23	1.0 ug/l			70 - 130	20	70 - 130	20
Bromoform	0.37	2.0 ug/l			62 - 126	20	67 - 122	20
Bromomethane	0.67	4.0 ug/l			55 - 136	24	64 - 132	20
2-Butanone (MEK)	2.2	10 ug/l			22 - 150	31	48 - 150	33
n-Butylbenzene	0.21	1.0 ug/l			70 - 130	20	70 - 130	20
sec-Butylbenzene	0.23	1.0 ug/l			70 - 130	20	70 - 130	20
tert-Butylbenzene	0.25	1.0 ug/l			70 - 130	20	70 - 130	20
Carbon disulfide	0.86	5.0 ug/l			56 - 132	20	61 - 126	20
Carbon tetrachloride	0.15	1.0 ug/l			76 - 131	20	70 - 130	20
Chlorobenzene	0.17	1.0 ug/l			70 - 130	20	70 - 130	20
Chloroethane	0.25	4.0 ug/l			67 - 134	20	69 - 128	20
Chloroform	0.13	1.0 ug/l			70 - 130	20	70 - 130	20
Chloromethane	0.21	4.0 ug/l			50 - 135	20	56 - 131	20
2-Chlorotoluene	0.17	1.0 ug/l			70 - 130	20	70 - 130	20
4-Chlorotoluene	0.20	1.0 ug/l			70 - 130	20	70 - 130	20
Dibromochloromethane	0.22	1.0 ug/l			70 - 130	20	70 - 130	20
1,2-Dibromo-3-chloropropane	0.82	2.0 ug/l			60 - 135	29	63 - 129	25
1,2-Dibromoethane (EDB)	0.30	1.0 ug/l			70 - 130	20	70 - 130	20
Dibromomethane	0.26	1.0 ug/l			70 - 130	20	70 - 130	20
1,2-Dichlorobenzene	0.22	1.0 ug/l			70 - 130	20	70 - 130	20
1,3-Dichlorobenzene	0.14	1.0 ug/l			70 - 130	20	70 - 130	20
1,4-Dichlorobenzene	0.17	1.0 ug/l			70 - 130	20	70 - 130	20
Dichlorodifluoromethane	0.15	4.0 ug/l			36 - 150	22	42 - 150	20
1,1-Dichloroethane	0.14	1.0 ug/l			70 - 130	20	70 - 130	20
1,2-Dichloroethane	0.31	1.0 ug/l			68 - 143	20	72 - 133	20
1,1-Dichloroethene	0.23	2.0 ug/l			70 - 130	20	70 - 130	20
cis-1,2-Dichloroethene	0.21	1.0 ug/l			70 - 130	20	70 - 130	20
trans-1,2-Dichloroethene	0.29	1.0 ug/l			70 - 130	20	70 - 130	20
1,2-Dichloropropane	0.23	1.0 ug/l			70 - 130	20	70 - 130	20
1,3-Dichloropropane	0.23	1.0 ug/l			70 - 130	20	70 - 130	20
2,2-Dichloropropane	0.18	1.0 ug/l			66 - 130	20	70 - 130	20
1,1-Dichloropropene	0.20	1.0 ug/l			70 - 130	20	70 - 130	20
cis-1,3-Dichloropropene	0.14	1.0 ug/l			70 - 130	20	70 - 130	20
trans-1,3-Dichloropropene	0.47	1.0 ug/l			71 - 132	20	70 - 130	20
Ethylbenzene	0.32	2.0 ug/l			70 - 130	20	70 - 130	20
Hexachlorobutadiene	0.28	1.0 ug/l			66 - 129	21	70 - 130	20
2-Hexanone	1.5	10 ug/l			18 - 150	25	44 - 150	31
Iodomethane	0.21	2.0 ug/l			47 - 141	29	58 - 138	25
Isopropylbenzene	0.26	1.0 ug/l			78 - 137	20	70 - 130	20
p-Isopropyltoluene	0.21	1.0 ug/l			70 - 130	20	70 - 130	20
Methylene Chloride	0.67	4.0 ug/l			74 - 132	20	70 - 130	20
4-Methyl-2-pentanone (MIBK)	1.3	10 ug/l			56 - 145	26	61 - 142	22
Methyl-tert-butyl Ether (MTBE)	0.22	5.0 ug/l			67 - 138	21	70 - 130	20
Naphthalene	0.51	2.0 ug/l			54 - 135	33	65 - 129	20

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VOLATILE ORGANICS (EPA 8260B) in WATER (EPA 8260B)

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	BlankSpike/LCS %R	BlankSpike/LCS RPD
n-Propylbenzene	0.21	1.0 ug/l			70 - 130	20	70 - 130	20
Styrene	0.17	1.0 ug/l			51 - 123	21	70 - 130	20
1,1,1,2-Tetrachloroethane	0.35	1.0 ug/l			70 - 130	20	70 - 130	20
1,1,2,2-Tetrachloroethane	0.33	2.0 ug/l			69 - 133	20	70 - 130	20
Tetrachloroethene	0.18	1.0 ug/l			70 - 130	20	70 - 130	20
Toluene	0.28	2.0 ug/l			70 - 130	20	70 - 130	20
1,2,3-Trichlorobenzene	0.45	1.0 ug/l			70 - 130	20	70 - 130	20
1,2,4-Trichlorobenzene	0.32	1.0 ug/l			66 - 126	20	70 - 130	20
1,1,1-Trichloroethane	0.15	1.0 ug/l			76 - 132	20	70 - 130	20
1,1,2-Trichloroethane	0.31	1.0 ug/l			70 - 130	20	70 - 130	20
Trichloroethene	0.24	1.0 ug/l			70 - 130	20	70 - 130	20
Trichlorofluoromethane	0.15	4.0 ug/l			74 - 150	20	78 - 149	20
1,2,3-Trichloropropane	0.78	1.0 ug/l			70 - 130	20	70 - 130	20
1,2,4-Trimethylbenzene	0.25	1.0 ug/l			70 - 130	20	70 - 130	20
1,3,5-Trimethylbenzene	0.21	1.0 ug/l			61 - 138	33	70 - 130	20
Vinyl Acetate	0.81	5.0 ug/l			50 - 150	23	57 - 149	21
Vinyl chloride	0.18	1.0 ug/l			58 - 139	21	66 - 134	20
Xylenes, Total	0.86	3.0 ug/l			70 - 130	20	70 - 130	20
*1,3-Butadiene	0.14	2.0 ug/l			70 - 130	20	7 - 130	20
*n-Hexane	1.6	2.0 ug/l			70 - 130	20	70 - 130	20
Sur: Dibromofluoromethane			70 - 130					
Sur: Toluene-d8			70 - 130					
Sur: 4-Bromofluorobenzene			70 - 130					
*o-Xylene	0.42	1.0 ug/l				20		20
*m,p-Xylenes	0.44	2.0 ug/l				20		20

* - Analyte not a part of normal reporting list. Special request only.

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ANALYTICAL METHOD INFORMATION FOR GROUP ANALYSES

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TESTAMERICA QUALITY CONTROL TIERS

Level I. Standard QC Data Package Provided With All Reports

A. Analytical Report
B. Chain of Custody (COC) Form
C. Report Detection Limits Listed on All Reports

Level II. Secondary QC Data Package Provided With All Reports

A. Analytical Report
B. Chain of Custody (COC) Form
C. Method Blank
D. Matrix Spike / Matrix Spike Duplicate Summary (MS/MSD)
E. LCS
F. Report Detection Limits Listed on All Reports
G. Case Narrative
H. Corrective Action Reports when necessary

Level III. Tertiary Data Package Provided Upon Request

A. All QC Data Included In Levels I and II plus
B. MS/MSD analysis performed on specific sample upon request
C. Chromatograms, including QC and Samples
D. Quantitation reports
E. Initial and Continuing Calibration Information
F. Analysis Logs
G. Extraction / Preparation Logs

Level IV. Quaternary Data Package Provided Upon Request
(CLP-TYPE Validation package)

A. All QC Data Included In Levels I, II, and III plus:
B. Multiple Sample Dilutions Reported
C. Initial and Continuing Calibration Chromatograms and Quantitaion Reports
D. Standard Preparation Log

Electronic Data Deliverables available upon request.

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PRICE QUOTE FOR LABORATORY SERVICES

Client:	Haley & Aldrich - Tucson	**Phone:**	(520) 289-8600
Client Contact:	Laura Davis	**Fax:**	(520) 289-8675
Client Address:	600 South Meyer Avenue, Suite 100 - Tucson, AZ 85701-2554	**Date:**	November 28, 2011
PO#/Contract#:	None	**Quote Expires:**	December 31, 2012
Project/Bid Name:	Phoenix-Goodyear Airport-North Years 1-3	**Expected Start Date:**	November 28, 2011

The Project Description Phoenix-Goodyear Airport-North Years 1-3, MUST be present on the chain of custody to receive the following discounted prices

Method	Description	Matrix	TAT	Quantity	Unit Price	Subtotal	Rush Charge	Total
SM 2320B	Alkalinity (CaCO3)	Water	Standard	315	$13.00	$4,095.00	NA	$4,095.00
EPA 300.0	Chloride (EPA 300.0)	Water	Standard	315	$13.00	$4,095.00	NA	$4,095.00
EPA 200.7	Dis Iron (200.7)	Water	Standard	315	$9.00	$2,835.00	NA	$2,835.00
EPA 200.7	ICP Calcium (200.7)	Water	Standard	315	$9.00	$2,835.00	NA	$2,835.00
EPA 200.7	ICP Iron (200.7)	Water	Standard	315	$9.00	$2,835.00	NA	$2,835.00
EPA 200.7	ICP Magnesium (200.7)	Water	Standard	315	$9.00	$2,835.00	NA	$2,835.00
EPA 200.7	ICP Manganese (200.7)	Water	Standard	315	$9.00	$2,835.00	NA	$2,835.00
EPA 314.0	Perchlorate (314.0)	Water	Standard	315	$60.00	$18,900.00	NA	$18,900.00
EPA 300.0	Sulfate (EPA 300.0)	Water	Standard	315	$13.00	$4,095.00	NA	$4,095.00
EPA 8260B	Volatile Organics (EPA 8260B)	Water	Standard	315	$60.00	$18,900.00	NA	$18,900.00
Bid Total:					**$204.00**	**$64,260.00**		**$64,260.00**

* Each invoice is subject to an Environmental Management Fee.
** TestAmerica's minimum charge for a group of samples received and logged in together at the laboratory is $100. Groups of samples received that require services totaling less than $100 will be charged a $100 minimum transaction fee for the sample group.

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COMMENTS

Methanol Kit price is $2.50 each.

Sincerely,

TestAmerica Laboratories, Inc.

Elizabeth Baker

Monday, November 28, 2011 11:28:29AM

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Fax: (602) 454-9303
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TestAmerica Terms and Conditions of Sale

Where a purchaser (Client) places an order for laboratory, consulting or sampling services from TestAmerica Laboratories, Inc., a Delaware corporation (referred to as "TestAmerica"), TestAmerica shall provide the ordered services pursuant to these Terms and Conditions, and the related Quotation or Price Schedule, or as agreed in a negotiated contract. In the absence of a written agreement to the contrary, the Order constitutes an acceptance by the Client of TestAmerica's offer to do business under these Terms and Conditions, and an agreement to be bound by these Terms and Conditions. No contrary or additional terms and conditions expressed in a Client's document shall be deemed to become a part of the contract created upon acceptance of these Terms and Conditions, unless accepted by TestAmerica in writing.

1. ORDERS AND RECEIPT OF SAMPLES

1.1 The Client may place the Order (i.e., specify a Scope of Work) either by submitting a purchase order to TestAmerica in writing or by telephone subsequently confirmed in writing, or by negotiated contract. Whichever option the Client selects for placing the Order, the Order shall not be valid unless it contains sufficient specification to enable TestAmerica to carry out the Client's requirements. In particular, samples must be accompanied by: a) adequate instruction on type of analysis requested, and b) complete written disclosure of the known or suspected presence of any hazardous substances, as defined by applicable federal or state law. Where any samples which were not accompanied by the required disclosure, cause interruptions in the lab's ability to process work due to contamination of instruments or work areas, the Client will be responsible for the costs of clean up and recovery.

1.2 The Client shall provide one week's advance notice of the sample delivery schedule, or any changes to the schedule, whenever possible. Upon timely delivery of samples, TestAmerica will use its best efforts to meet mutually agreed turnaround times. All turnaround times will be calculated from the point in time when TestAmerica has determined that it can proceed with defined work following receipt, inspection of samples, and resolution of any discrepancies in Chain-of-Custody forms and project guidance regarding work to be done (Sample Delivery Acceptance). In the event of any changes in the sample delivery schedule by the Client, prior to Sample Delivery Acceptance, TestAmerica reserves the right to modify its turnaround time commitment, to change the date upon which TestAmerica will accept samples, or refuse Sample Delivery Acceptance for the affected samples.

1.3 TestAmerica reserves the right, exercisable at any time, to refuse or revoke Sample Delivery Acceptance for any sample which in the sole judgment of TestAmerica: a) is of unsuitable volume; b) may pose a risk or become unsuitable for handling, transport, or processing for any health, safety, environmental or other reason, whether or not due to the presence in the sample of any hazardous substance and whether or not such presence has been disclosed to TestAmerica by the Client; or c) holding times cannot be met, due to passage of more than 48 hours from the time of sampling or 1/2 the holding time for the requested test, whichever is less.

1.4 Prior to Sample Delivery Acceptance, the entire risk of loss or damage to samples remains with the Client, except where TestAmerica provides courier services. In no event will TestAmerica have any responsibility or liability for the action or inaction of any carrier shipping or delivering any sample to or from TestAmerica's premises. Client is responsible to assure that any sample containing any hazardous substance which is to be delivered to TestAmerica's premises will be packaged, labeled, transported and delivered properly and in accordance with applicable laws.

2. PAYMENT TERMS

2.1 Services performed by TestAmerica will be in accordance with prices quoted and later confirmed in writing or as stated in the Price Schedule. Where reports are issued in or delivered to a state which assesses sales tax on TestAmerica's services, applicable sales taxes will be added to the invoice as required by law, unless an appropriate sales tax exemption form is on file with TestAmerica. Where requested services on a group of samples received and logged in together at the laboratory total less than $100, there will be a minimum transaction charge of $100 for the sample group, or as shown on any related quote from TestAmerica. An Environmental Management Fee of 5% of the invoice value will also be applied, at TestAmerica's discretion.

2.2 Invoices may be submitted to Client upon completion of any sample delivery group. Billing corrections must be requested within 30 days of invoice date. Payment in advance is required for all Clients except those whose credit has been
established with TestAmerica. For Clients with approved credit, payment terms are net 30 days days of invoice date. Payment in advance is required for all Clients except those whose credit has been established with TestAmerica. For Clients with approved credit, payment terms are net 30 days from the date of invoice by TestAmerica. All overdue payments are subject to an additional interest and service charge of one and one-half percent (1.5%) (or the maximum rate permissible by law, whichever is lesser) per month or portion thereof from the due date until the date of payment. All fees are charged or billed directly to the Client. The billing of a third party will not be accepted without a statement, signed by the third party that acknowledges and accepts payment responsibility.

2.3 TestAmerica may suspend work and withhold delivery of data under this order at any time in the event Client fails to make timely payment of its invoices. Client shall be responsible for all costs and expenses of collection including reasonable attorney's fees. TestAmerica reserves the right to refuse to proceed with work at any time based upon an unfavorable Client credit report.

3. CHANGE ORDERS, TERMINATION

3.1 Changes to the Scope of Work, price, or result delivery date may be initiated by TestAmerica after Sample Delivery Acceptance due to any condition which conflicts with analytical, QA or other protocols warranted in these Terms and Conditions. TestAmerica will not proceed with such changes until an agreement with the Client is reached on the amount of any cost, schedule change or technical change to the Scope of Work, and such agreement is documented in writing.

3.2 Changes to the Scope of Work, including but not limited to increasing or decreasing the work, changing test and analysis specification, or acceleration in the performance of the work may be initiated by the Client after sample delivery acceptance. Such a change will be documented in writing and may result in a change in cost and turnaround time commitment. TestAmerica's acceptance of such changes is contingent upon technical feasibility and operational capacity.

3.3 Suspension or termination of all or any part of the work may be initiated by the Client. TestAmerica will be compensated consistent with Section 2 of these Terms and Conditions. TestAmerica will complete all work in progress and be paid in full for all work completed.

4. WARRANTIES AND LIABILITY

4.1 Where applicable, TestAmerica will use analytical methodologies which are in substantial conformity with published test methods. TestAmerica has implemented these methods in its Laboratory Quality Manuals and referenced Standard Operating Procedures and where the nature or composition of the sample requires it, TestAmerica reserves the right to deviate from these methodologies as necessary or appropriate, based on the reasonable judgment of TestAmerica, which deviations, if any, will be made on a basis consistent with recognized standards of the industry and/or TestAmerica's Laboratory Quality Manuals. Client may request that TestAmerica perform according to a mutually agreed Quality Assurance Project Plan (QAPP). In the event that samples arrive prior to agreement on a QAPP, TestAmerica will proceed with analyses under its standard Quality Manuals then in effect, and TestAmerica will not be responsible for any resampling or other charges if work must be repeated to comply with a subsequently finalized QAPP.

4.2 TestAmerica shall start preparation and/or analysis within holding times provided that Sample Delivery Acceptance occurs within 48 hours of sampling or 1/2 of the holding time for the test, whichever is less. Where resolution of inconsistencies leading to Sample Delivery Acceptance does not occur within this period, TestAmerica will use its best efforts to meet holding times and will proceed with the work provided that, in TestAmerica's judgment, the chain-of-custody or definition of the Scope of Work provide sufficient guidance. Reanalysis of samples to comply with TestAmerica's Quality Manuals will be deemed to have met holding times provided the initial analysis was performed within the applicable holding time. Where reanalysis demonstrates that sample matrix interference is the cause of failure to meet any Quality Manual requirements, the warranty will be deemed to have been met.

4.3 TestAmerica warrants that it possesses and maintains all licenses and certifications which are required to perform services under these Terms and Conditions provided that such requirements are specified in writing to TestAmerica prior to Sample Delivery Acceptance. TestAmerica will notify the Client in writing of any decertification or revocation of any license, or notice of either, which affects work in progress.

4.4 The warranty obligations set forth in Sections 4.1, 4.2 and 4.3 are the sole and exclusive warranties given by TestAmerica in connection with any services performed by TestAmerica or any Results generated from such services, and TestAmerica gives and makes NO OTHER REPRESENTATION OR WARRANTY OF ANY KIND,

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EXPRESS OR IMPLIED. No representative of TestAmerica is authorized to give or make any other representation or warranty or modify this warranty in any way.

4.5 Client's sole and exclusive remedy for the breach of warranty in connection with any services performed by TestAmerica, will be limited to repeating any services performed, contingent on the Client's providing, at the request of TestAmerica and at the Client's expense, additional sample(s) if necessary. Any reanalysis requested by the Client generating Results consistent with the original Results will be at the Client's expense. If resampling is necessary, TestAmerica's liability for resampling costs will be limited to actual cost or one hundred and fifty dollars ($150) per sample, whichever is less.

4.6 TestAmerica's liability for any and all causes of action arising hereunder, whether based in contract, tort, warranty, negligence or otherwise, shall be limited to the lesser amount of compensation for the services performed or $100,000. All claims, including those for negligence, shall be deemed waived unless suit thereon is filed within one year after TestAmerica's completion of the services. Under no circumstances, whether arising in contract, tort (including negligence), or otherwise, shall TestAmerica be responsible for loss of use, loss of profits, or for any special, indirect, incidental or consequential damages occasioned by the services performed or by application or use of the reports prepared.

4.7 In no event shall TestAmerica have any responsibility or liability to the Client for any failure or delay in performance by TestAmerica which results, directly or indirectly, in whole or in part, from any cause or circumstance beyond the reasonable control of TestAmerica. Such causes and circumstances shall include, but not be limited to, acts of God, acts of Client, acts or orders of any governmental authority, strikes or other labor disputes, natural disasters, accidents, wars, civil disturbances, equipment breakdown, matrix interference or unknown highly contaminated samples that impact instrument operation, unavailability of supplies from usual suppliers, difficulties or delays in transportation, mail or delivery services, or any other cause beyond TestAmerica's reasonable control.

5. RESULTS, WORK PRODUCT

5.1 Data or information provided to TestAmerica or generated by services performed under this agreement shall only become the property of the Client upon receipt in full by TestAmerica of payment for the whole Order. Ownership of any analytical method, QA/QC protocols, software programs or equipment developed by TestAmerica for performance of work will be retained by TestAmerica, and Client shall not disclose such information to any third party.

5.2 Data and sample materials provided by Client or at Client’s request, and the result obtained by TestAmerica shall be held in confidence (unless such information is generally available to the public or is in the public domain or Client has failed to pay TestAmerica for all services rendered or is otherwise in breach of these Terms and Conditions), subject to any disclosure required by law or legal process.

5.3 Should the Results delivered by TestAmerica be used by the Client or Client's client, even though subsequently determined not to meet the warranties described in these Terms and Conditions, then the compensation will be adjusted based upon mutual agreement. In no case shall the Client unreasonably withhold TestAmerica's right to independently defend its data.

5.4 TestAmerica reserves the right to perform the services at any laboratory in the TestAmerica network, unless the Client has specified a particular location for the work. In addition, TestAmerica reserves the right to subcontract services ordered by the Client to another laboratory or laboratories, if, in TestAmerica's sole judgment, it is reasonably necessary, appropriate or advisable to do so. TestAmerica will in no way be liable for any subcontracted services (outside the TestAmerica network) except for work performed at laboratories which have been audited and approved by TestAmerica.

5.5 TestAmerica shall dispose of the Client's samples 30 days after the analytical report is issued, unless instructed to store them for an alternate period of time or to return such samples to the Client, in a manner consistent with U.S. Environmental Protection Agency regulations or other applicable federal, state or local requirements. Air samples in Summa canisters will be retained for 5 days after analysis and data review. Longer storage periods may be requested and may be accommodated as space allows for an additional charge. Any samples for projects that are canceled or not accepted, or for which return was requested, will be returned to the Client at his own expense. TestAmerica reserves the right to return to the Client any sample or unused portion of a sample that is not within TestAmerica's permitted capability or the capabilities of TestAmerica's designated waste disposal vendor(s). ALL DIOXIN, MIXED WASTE, AND RADIOACTIVE SAMPLES WILL BE RETURNED TO THE CLIENT, unless prior arrangements for disposal are made.

5.6 Unless a different time period is agreed to in any order under these Terms and Conditions, TestAmerica agrees to retain all records for five (5) years.

5.7 In the event that TestAmerica is required to respond to legal process related to services for Client, Client agrees to reimburse TestAmerica for hourly charges for personnel involved in the response and attorney fees reasonably incurred in obtaining advice concerning the response, preparation to testify, and appearances related to the legal process, travel and all reasonable expenses associated with the litigation.

6. INSURANCE

6.1 TestAmerica shall maintain in force during the performance of services under these Terms and Conditions, Workers' Compensation and Employer's Liability Insurance in accordance with the laws of the states having jurisdiction over TestAmerica's employees who are engaged in the performance of the work. TestAmerica shall also maintain during such period, Comprehensive General and Contractual Liability (limit of $1,000,000 per occurrence/ $2,000,000aggregate), Comprehensive Automobile Liability, owned and hired, ($1,000,000 combined single limit), and Professional/Pollution Liability Insurance (limit of $5,000,000 per occurrence/aggregate).

7. AUDIT

7.1 Upon prior notice to TestAmerica, the Client may audit and inspect TestAmerica's records and accounts covering reimbursable costs related to work done for the Client, for a period of two (2) years after completion of the work. The purpose of any such audit shall be only for verification of such costs, and TestAmerica shall not be required to provide access to cost records where prices are expressed as fixed fees or published unit prices.

8. MISCELLANEOUS PROVISIONS

8.1 These Terms and Conditions, together with any additions or revisions which may be agreed to in writing by TestAmerica, embody the whole agreement of the parties and provide the only remedies available. There are no promises, terms, conditions, understandings, obligations or agreements other than those contained herein, and these Terms and Conditions shall supersede all previous communications, representations, or agreements, either verbal or written, between the Client and TestAmerica. These Terms and Conditions, and any transactions or agreements to which they apply, shall be governed both as to interpretation and performance by the laws of the state where TestAmerica's services are performed.

8.2 The invalidity or unenforceability, in whole or in part of any provision, term or condition hereof shall not affect in any way the validity or enforceability of the remainder to these Terms and Conditions, the intent of the parties being that the provisions be severable. The section headings of these Terms and Conditions are intended solely for convenient reference and shall not define, limit or affect in any way these Terms and Conditions or their interpretations. No waiver by either party of any provision, term or condition hereof or of any obligation of the other party hereunder shall constitute a waiver of any subsequent breach or other obligation.

8.3 The obligations, liabilities, and remedies of the parties, as provided herein, are exclusive and in lieu of any others available at law or in equity. Indemnifications, releases from liability and limitations of liability shall apply, notwithstanding the fault, negligence or strict liability of the party to be indemnified, released, or whose liability is limited, except to the extent of sole negligence or willful misconduct.

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Phoenix, AZ 85040
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TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

TURNAROUND TIME PRICING

ALKALINITY (CACO3) in WATER

Same Day Rush	1 Day Rush	2 Day Rush	3 Day Rush	5 Day Rush	Standard TAT
$39.00	$26.00	$22.75	$19.50	$13.00	$13.00

CHLORIDE (EPA 300.0) in WATER

Same Day Rush	1 Day Rush	2 Day Rush	3 Day Rush	5 Day Rush	Standard TAT
$39.00	$26.00	$22.75	$19.50	$13.00	$13.00

DIS IRON (200.7) in WATER

Same Day Rush	1 Day Rush	2 Day Rush	3 Day Rush	5 Day Rush	Standard TAT
$27.00	$18.00	$15.75	$13.50	$9.00	$9.00

ICP CALCIUM (200.7) in WATER

Same Day Rush	1 Day Rush	2 Day Rush	3 Day Rush	5 Day Rush	Standard TAT
$27.00	$18.00	$15.75	$13.50	$9.00	$9.00

ICP IRON (200.7) in WATER

Same Day Rush	1 Day Rush	2 Day Rush	3 Day Rush	5 Day Rush	Standard TAT
$27.00	$18.00	$15.75	$13.50	$9.00	$9.00

ICP MAGNESIUM (200.7) in WATER

Same Day Rush	1 Day Rush	2 Day Rush	3 Day Rush	5 Day Rush	Standard TAT
$27.00	$18.00	$15.75	$13.50	$9.00	$9.00

ICP MANGANESE (200.7) in WATER

Same Day Rush	1 Day Rush	2 Day Rush	3 Day Rush	5 Day Rush	Standard TAT
$27.00	$18.00	$15.75	$13.50	$9.00	$9.00

PERCHLORATE (314.0) in WATER

Same Day Rush	1 Day Rush	2 Day Rush	3 Day Rush	5 Day Rush	Standard TAT
$180.00	$120.00	$105.00	$90.00	$60.00	$60.00

SULFATE (EPA 300.0) in WATER

Same Day Rush	1 Day Rush	2 Day Rush	3 Day Rush	5 Day Rush	Standard TAT
$39.00	$26.00	$22.75	$19.50	$13.00	$13.00

VOLATILE ORGANICS (EPA 8260B) in WATER

Same Day Rush	1 Day Rush	2 Day Rush	3 Day Rush	5 Day Rush	Standard TAT
$180.00	$120.00	$105.00	$90.00	$60.00	$60.00

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ANALYTICAL METHOD INFORMATION

ALKALINITY (CACO3) in WATER (SM 2320B)

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	BlankSpike/LCS %R	BlankSpike/LCS RPD
Alkalinity as CaCO3	1.5	6.0 mg/l		20			90 - 110	20
Bicarbonate Alkalinity as CaCO3	6.0	6.0 mg/l		20				
Carbonate Alkalinity as CaCO3	6.0	6.0 mg/l		20				
Hydroxide Alkalinity as CaCO3	6.0	6.0 mg/l		20				
Alkalinity, Phenolphthalein	6.0	6.0 mg/l		20				

* - Analyte not a part of normal reporting list. Special request only.

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CHLORIDE (EPA 300.0) in WATER (EPA 300.0)

		Reporting Limit	Surrogate	Duplicate	Matrix Spike		BlankSpike/LCS	
Analyte	MDL		%R	RPD	%R	RPD	%R	RPD
Chloride	0.056	2.0 mg/l			80 - 120	15	90 - 110	15

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DIS IRON (200.7) in WATER (EPA 200.7)

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	BlankSpike/LCS %R	BlankSpike/LCS RPD
Iron	0.031	0.050 mg/l			70 - 130	20	85 - 115	20

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ICP CALCIUM (200.7) in WATER (EPA 200.7)

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	BlankSpike/LCS %R	BlankSpike/LCS RPD
Calcium	0.25	2.0 mg/l			70 - 130	20	85 - 115	20

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ICP IRON (200.7) in WATER (EPA 200.7)

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	BlankSpike/LCS %R	BlankSpike/LCS RPD
Iron	0.031	0.050 mg/l			70 - 130	20	85 - 115	20

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ICP MAGNESIUM (200.7) in WATER (EPA 200.7)

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	BlankSpike/LCS %R	BlankSpike/LCS RPD
Magnesium	0.20	2.0 mg/l			70 - 130	20	85 - 115	20

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ICP MANGANESE (200.7) in WATER (EPA 200.7)

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	BlankSpike/LCS %R	BlankSpike/LCS RPD
Manganese	0.0096	0.010 mg/l			70 - 130	20	85 - 115	20

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PERCHLORATE (314.0) in WATER (EPA 314.0)

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	BlankSpike/LCS %R	BlankSpike/LCS RPD
Perchlorate	0.47	2.0 ug/l		15	80 - 120	15	85 - 115	15

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SULFATE (EPA 300.0) in WATER (EPA 300.0)

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	BlankSpike/LCS %R	BlankSpike/LCS RPD
Sulfate	0.091	2.0 mg/l		15	80 - 120	15	90 - 110	15

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VOLATILE ORGANICS (EPA 8260B) in WATER (EPA 8260B)

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	BlankSpike/LCS %R	BlankSpike/LCS RPD
Acetone	7.3	20 ug/l			10 - 150	35	30 - 150	35
Benzene	0.12	1.0 ug/l			70 - 130	20	70 - 130	20
Bromobenzene	0.14	1.0 ug/l			70 - 130	20	70 - 130	20
Bromochloromethane	0.27	1.0 ug/l			70 - 130	20	70 - 130	20
Bromodichloromethane	0.23	1.0 ug/l			70 - 130	20	70 - 130	20
Bromoform	0.37	2.0 ug/l			62 - 126	20	67 - 122	20
Bromomethane	0.67	4.0 ug/l			55 - 136	24	64 - 132	20
2-Butanone (MEK)	2.2	10 ug/l			22 - 150	31	48 - 150	33
n-Butylbenzene	0.21	1.0 ug/l			70 - 130	20	70 - 130	20
sec-Butylbenzene	0.23	1.0 ug/l			70 - 130	20	70 - 130	20
tert-Butylbenzene	0.25	1.0 ug/l			70 - 130	20	70 - 130	20
Carbon disulfide	0.86	5.0 ug/l			56 - 132	20	61 - 126	20
Carbon tetrachloride	0.15	1.0 ug/l			76 - 131	20	70 - 130	20
Chlorobenzene	0.17	1.0 ug/l			70 - 130	20	70 - 130	20
Chloroethane	0.25	4.0 ug/l			67 - 134	20	69 - 128	20
Chloroform	0.13	1.0 ug/l			70 - 130	20	70 - 130	20
Chloromethane	0.21	4.0 ug/l			50 - 135	20	56 - 131	20
2-Chlorotoluene	0.17	1.0 ug/l			70 - 130	20	70 - 130	20
4-Chlorotoluene	0.20	1.0 ug/l			70 - 130	20	70 - 130	20
Dibromochloromethane	0.22	1.0 ug/l			70 - 130	20	70 - 130	20
1,2-Dibromo-3-chloropropane	0.82	2.0 ug/l			60 - 135	29	63 - 129	25
1,2-Dibromoethane (EDB)	0.30	1.0 ug/l			70 - 130	20	70 - 130	20
Dibromomethane	0.26	1.0 ug/l			70 - 130	20	70 - 130	20
1,2-Dichlorobenzene	0.22	1.0 ug/l			70 - 130	20	70 - 130	20
1,3-Dichlorobenzene	0.14	1.0 ug/l			70 - 130	20	70 - 130	20
1,4-Dichlorobenzene	0.17	1.0 ug/l			70 - 130	20	70 - 130	20
Dichlorodifluoromethane	0.15	4.0 ug/l			36 - 150	22	42 - 150	20
1,1-Dichloroethane	0.14	1.0 ug/l			70 - 130	20	70 - 130	20
1,2-Dichloroethane	0.31	1.0 ug/l			68 - 143	20	72 - 133	20
1,1-Dichloroethene	0.23	2.0 ug/l			70 - 130	20	70 - 130	20
cis-1,2-Dichloroethene	0.21	1.0 ug/l			70 - 130	20	70 - 130	20
trans-1,2-Dichloroethene	0.29	1.0 ug/l			70 - 130	20	70 - 130	20
1,2-Dichloropropane	0.23	1.0 ug/l			70 - 130	20	70 - 130	20
1,3-Dichloropropane	0.23	1.0 ug/l			70 - 130	20	70 - 130	20
2,2-Dichloropropane	0.18	1.0 ug/l			66 - 130	20	70 - 130	20
1,1-Dichloropropene	0.20	1.0 ug/l			70 - 130	20	70 - 130	20
cis-1,3-Dichloropropene	0.14	1.0 ug/l			70 - 130	20	70 - 130	20
trans-1,3-Dichloropropene	0.47	1.0 ug/l			71 - 132	20	70 - 130	20
Ethylbenzene	0.32	2.0 ug/l			70 - 130	20	70 - 130	20
Hexachlorobutadiene	0.28	1.0 ug/l			66 - 129	21	70 - 130	20
2-Hexanone	1.5	10 ug/l			18 - 150	25	44 - 150	31
Iodomethane	0.21	2.0 ug/l			47 - 141	29	58 - 138	25
Isopropylbenzene	0.26	1.0 ug/l			78 - 137	20	70 - 130	20
p-Isopropyltoluene	0.21	1.0 ug/l			70 - 130	20	70 - 130	20
Methylene Chloride	0.67	4.0 ug/l			74 - 132	20	70 - 130	20
4-Methyl-2-pentanone (MIBK)	1.3	10 ug/l			56 - 145	26	61 - 142	22
Methyl-tert-butyl Ether (MTBE)	0.22	5.0 ug/l			67 - 138	21	70 - 130	20
Naphthalene	0.51	2.0 ug/l			54 - 135	33	65 - 129	20

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VOLATILE ORGANICS (EPA 8260B) in WATER (EPA 8260B)

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	BlankSpike/LCS %R	BlankSpike/LCS RPD
n-Propylbenzene	0.21	1.0 ug/l			70 - 130	20	70 - 130	20
Styrene	0.17	1.0 ug/l			51 - 123	21	70 - 130	20
1,1,1,2-Tetrachloroethane	0.35	1.0 ug/l			70 - 130	20	70 - 130	20
1,1,2,2-Tetrachloroethane	0.33	2.0 ug/l			69 - 133	20	70 - 130	20
Tetrachloroethene	0.18	1.0 ug/l			70 - 130	20	70 - 130	20
Toluene	0.28	2.0 ug/l			70 - 130	20	70 - 130	20
1,2,3-Trichlorobenzene	0.45	1.0 ug/l			70 - 130	20	70 - 130	20
1,2,4-Trichlorobenzene	0.32	1.0 ug/l			66 - 126	20	70 - 130	20
1,1,1-Trichloroethane	0.15	1.0 ug/l			76 - 132	20	70 - 130	20
1,1,2-Trichloroethane	0.31	1.0 ug/l			70 - 130	20	70 - 130	20
Trichloroethene	0.24	1.0 ug/l			70 - 130	20	70 - 130	20
Trichlorofluoromethane	0.15	4.0 ug/l			74 - 150	20	78 - 149	20
1,2,3-Trichloropropane	0.78	1.0 ug/l			70 - 130	20	70 - 130	20
1,2,4-Trimethylbenzene	0.25	1.0 ug/l			70 - 130	20	70 - 130	20
1,3,5-Trimethylbenzene	0.21	1.0 ug/l			61 - 138	33	70 - 130	20
Vinyl Acetate	0.81	5.0 ug/l			50 - 150	23	57 - 149	21
Vinyl chloride	0.18	1.0 ug/l			58 - 139	21	66 - 134	20
Xylenes, Total	0.86	3.0 ug/l			70 - 130	20	70 - 130	20
*1,3-Butadiene	0.14	2.0 ug/l			70 - 130	20	7 - 130	20
*n-Hexane	1.6	2.0 ug/l			70 - 130	20	70 - 130	20
Sur: Dibromofluoromethane			70 - 130					
Sur: Toluene-d8			70 - 130					
Sur: 4-Bromofluorobenzene			70 - 130					
*o-Xylene	0.42	1.0 ug/l				20		20
*m,p-Xylenes	0.44	2.0 ug/l				20		20

* - Analyte not a part of normal reporting list. Special request only.

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ANALYTICAL METHOD INFORMATION FOR GROUP ANALYSES

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TESTAMERICA QUALITY CONTROL TIERS

Level I. Standard QC Data Package Provided With All Reports

A. Analytical Report
B. Chain of Custody (COC) Form
C. Report Detection Limits Listed on All Reports

Level II. Secondary QC Data Package Provided With All Reports

A. Analytical Report
B. Chain of Custody (COC) Form
C. Method Blank
D. Matrix Spike / Matrix Spike Duplicate Summary (MS/MSD)
E. LCS
F. Report Detection Limits Listed on All Reports
G. Case Narrative
H. Corrective Action Reports when necessary

Level III. Tertiary Data Package Provided Upon Request

A. All QC Data Included In Levels I and II plus
B. MS/MSD analysis performed on specific sample upon request
C. Chromatograms, including QC and Samples
D. Quantitation reports
E. Initial and Continuing Calibration Information
F. Analysis Logs
G. Extraction / Preparation Logs

Level IV. Quaternary Data Package Provided Upon Request

(CLP-TYPE Validation package)

A. All QC Data Included In Levels I, II, and III plus:
B. Multiple Sample Dilutions Reported
C. Initial and Continuing Calibration Chromatograms and Quantitaion Reports
D. Standard Preparation Log

Electronic Data Deliverables available upon request.

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PRICE QUOTE FOR LABORATORY SERVICES

Client:	Haley & Aldrich - Tucson	**Phone:**	(520) 289-8600
Client Contact:	Laura Davis	**Fax:**	(520) 289-8675
Client Address:	600 South Meyer Avenue, Suite 100 - Tucson, AZ 85701-2554	**Date:**	November 28, 2011
PO#/Contract#:	None	**Quote Expires:**	December 31, 2012
Project/Bid Name:	Phoenix-Goodyear Airport-North Years 4-5	**Expected Start Date:**	November 28, 2011

The Project Description Phoenix-Goodyear Airport-North Years 4-5, MUST be present on the chain of custody to receive the following discounted prices

Method	Description	Matrix	TAT	Quantity	Unit Price	Subtotal	Rush Charge	Total
SM 2320B	Alkalinity (CaCO3)	Water	Standard	70	$14.00	$980.00	NA	$980.00
EPA 300.0	Chloride (EPA 300.0)	Water	Standard	70	$14.00	$980.00	NA	$980.00
EPA 200.7	Dis Iron (200.7)	Water	Standard	70	$9.75	$682.50	NA	$682.50
EPA 200.7	ICP Calcium (200.7)	Water	Standard	70	$9.75	$682.50	NA	$682.50
EPA 200.7	ICP Iron (200.7)	Water	Standard	70	$9.75	$682.50	NA	$682.50
EPA 200.7	ICP Magnesium (200.7)	Water	Standard	70	$9.75	$682.50	NA	$682.50
EPA 200.7	ICP Manganese (200.7)	Water	Standard	70	$9.75	$682.50	NA	$682.50
EPA 314.0	Perchlorate (314.0)	Water	Standard	70	$65.00	$4,550.00	NA	$4,550.00
EPA 300.0	Sulfate (EPA 300.0)	Water	Standard	70	$14.00	$980.00	NA	$980.00
EPA 8260B	Volatile Organics (EPA 8260B)	Water	Standard	70	$65.00	$4,550.00	NA	$4,550.00
Bid Total:					**$220.75**	**$15,452.50**		**$15,452.50**

* Each invoice is subject to an Environmental Management Fee.
** TestAmerica's minimum charge for a group of samples received and logged in together at the laboratory is $100. Groups of samples received that require services totaling less than $100 will be charged a $100 minimum transaction fee for the sample group.

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COMMENTS

Methanol Kit price is $2.50 each.

Sincerely,

TestAmerica Laboratories, Inc.

Elizabeth Baker

Monday, November 28, 2011 3:03:48PM

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TestAmerica Terms and Conditions of Sale

Where a purchaser (Client) places an order for laboratory, consulting or sampling services from TestAmerica Laboratories, Inc., a Delaware corporation (referred to as "TestAmerica"), TestAmerica shall provide the ordered services pursuant to these Terms and Conditions, and the related Quotation or Price Schedule, or as agreed in a negotiated contract. In the absence of a written agreement to the contrary, the Order constitutes an acceptance by the Client of TestAmerica's offer to do business under these Terms and Conditions, and an agreement to be bound by these Terms and Conditions. No contrary or additional terms and conditions expressed in a Client's document shall be deemed to become a part of the contract created upon acceptance of these Terms and Conditions, unless accepted by TestAmerica in writing.

1. ORDERS AND RECEIPT OF SAMPLES

1.1 The Client may place the Order (i.e., specify a Scope of Work) either by submitting a purchase order to TestAmerica in writing or by telephone subsequently confirmed in writing, or by negotiated contract. Whichever option the Client selects for placing the Order, the Order shall not be valid unless it contains sufficient specification to enable TestAmerica to carry out the Client's requirements. In particular, samples must be accompanied by: a) adequate instruction on type of analysis requested, and b) complete written disclosure of the known or suspected presence of any hazardous substances, as defined by applicable federal or state law. Where any samples which were not accompanied by the required disclosure, cause interruptions in the lab's ability to process work due to contamination of instruments or work areas, the Client will be responsible for the costs of clean up and recovery.

1.2 The Client shall provide one week's advance notice of the sample delivery schedule, or any changes to the schedule, whenever possible. Upon timely delivery of samples, TestAmerica will use its best efforts to meet mutually agreed turnaround times. All turnaround times will be calculated from the point in time when TestAmerica has determined that it can proceed with defined work following receipt, inspection of samples, and resolution of any discrepancies in Chain-of-Custody forms and project guidance regarding work to be done (Sample Delivery Acceptance). In the event of any changes in the sample delivery schedule by the Client, prior to Sample Delivery Acceptance, TestAmerica reserves the right to modify its turnaround time commitment, to change the date upon which TestAmerica will accept samples, or refuse Sample Delivery Acceptance for the affected samples.

1.3 TestAmerica reserves the right, exercisable at any time, to refuse or revoke Sample Delivery Acceptance for any sample which in the sole judgment of TestAmerica: a) is of unsuitable volume; b) may pose a risk or become unsuitable for handling, transport, or processing for any health, safety, environmental or other reason, whether or not due to the presence in the sample of any hazardous substance and whether or not such presence has been disclosed to TestAmerica by the Client; or c) holding times cannot be met, due to passage of more than 48 hours from the time of sampling or 1/2 the holding time for the requested test, whichever is less.

1.4 Prior to Sample Delivery Acceptance, the entire risk of loss or damage to samples remains with the Client, except where TestAmerica provides courier services. In no event will TestAmerica have any responsibility or liability for the action or inaction of any carrier shipping or delivering any sample to or from TestAmerica's premises. Client is responsible to assure that any sample containing any hazardous substance which is to be delivered to TestAmerica's premises will be packaged, labeled, transported and delivered properly and in accordance with applicable laws.

2. PAYMENT TERMS

2.1 Services performed by TestAmerica will be in accordance with prices quoted and later confirmed in writing or as stated in the Price Schedule. Where reports are issued in or delivered to a state which assesses sales tax on TestAmerica's services, applicable sales taxes will be added to the invoice as required by law, unless an appropriate sales tax exemption form is on file with TestAmerica. Where requested services on a group of samples received and logged in together at the laboratory total less than $100, there will be a minimum transaction charge of $100 for the sample group, or as shown on any related quote from TestAmerica. An Environmental Management Fee of 5% of the invoice value will also be applied, at TestAmerica's discretion.

2.2 Invoices may be submitted to Client upon completion of any sample delivery group. Billing corrections must be requested within 30 days of invoice date. Payment in advance is required for all Clients except those whose credit has been
established with TestAmerica. For Clients with approved credit, payment terms are net 30 days days of invoice date. Payment in advance is required for all Clients except those whose credit has been established with TestAmerica. For Clients with approved credit, payment terms are net 30 days from the date of invoice by TestAmerica. All overdue payments are subject to an additional interest and service charge of one and one-half percent (1.5%) (or the maximum rate permissible by law, whichever is lesser) per month or portion thereof from the due date until the date of payment. All fees are charged or billed directly to the Client. The billing of a third party will not be accepted without a statement, signed by the third party that acknowledges and accepts payment responsibility.

2.3 TestAmerica may suspend work and withhold delivery of data under this order at any time in the event Client fails to make timely payment of its invoices. Client shall be responsible for all costs and expenses of collection including reasonable attorney's fees. TestAmerica reserves the right to refuse to proceed with work at any time based upon an unfavorable Client credit report.

3. CHANGE ORDERS, TERMINATION

3.1 Changes to the Scope of Work, price, or result delivery date may be initiated by TestAmerica after Sample Delivery Acceptance due to any condition which conflicts with analytical, QA or other protocols warranted in these Terms and Conditions. TestAmerica will not proceed with such changes until an agreement with the Client is reached on the amount of any cost, schedule change or technical change to the Scope of Work, and such agreement is documented in writing.

3.2 Changes to the Scope of Work, including but not limited to increasing or decreasing the work, changing test and analysis specification, or acceleration in the performance of the work may be initiated by the Client after sample delivery acceptance. Such a change will be documented in writing and may result in a change in cost and turnaround time commitment. TestAmerica's acceptance of such changes is contingent upon technical feasibility and operational capacity.

3.3 Suspension or termination of all or any part of the work may be initiated by the Client. TestAmerica will be compensated consistent with Section 2 of these Terms and Conditions. TestAmerica will complete all work in progress and be paid in full for all work completed.

4. WARRANTIES AND LIABILITY

4.1 Where applicable, TestAmerica will use analytical methodologies which are in substantial conformity with published test methods. TestAmerica has implemented these methods in its Laboratory Quality Manuals and referenced Standard Operating Procedures and where the nature or composition of the sample requires it, TestAmerica reserves the right to deviate from these methodologies as necessary or appropriate, based on the reasonable judgment of TestAmerica, which deviations, if any, will be made on a basis consistent with recognized standards of the industry and/or TestAmerica's Laboratory Quality Manuals. Client may request that TestAmerica perform according to a mutually agreed Quality Assurance Project Plan (QAPP). In the event that samples arrive prior to agreement on a QAPP, TestAmerica will proceed with analyses under its standard Quality Manuals then in effect, and TestAmerica will not be responsible for any resampling or other charges if work must be repeated to comply with a subsequently finalized QAPP.

4.2 TestAmerica shall start preparation and/or analysis within holding times provided that Sample Delivery Acceptance occurs within 48 hours of sampling or 1/2 of the holding time for the test, whichever is less. Where resolution of inconsistencies leading to Sample Delivery Acceptance does not occur within this period, TestAmerica will use its best efforts to meet holding times and will proceed with the work provided that, in TestAmerica's judgment, the chain-of-custody or definition of the Scope of Work provide sufficient guidance. Reanalysis of samples to comply with TestAmerica's Quality Manuals will be deemed to have met holding times provided the initial analysis was performed within the applicable holding time. Where reanalysis demonstrates that sample matrix interference is the cause of failure to meet any Quality Manual requirements, the warranty will be deemed to have been met.

4.3 TestAmerica warrants that it possesses and maintains all licenses and certifications which are required to perform services under these Terms and Conditions provided that such requirements are specified in writing to TestAmerica prior to Sample Delivery Acceptance. TestAmerica will notify the Client in writing of any decertification or revocation of any license, or notice of either, which affects work in progress.

4.4 The warranty obligations set forth in Sections 4.1, 4.2 and 4.3 are the sole and exclusive warranties given by TestAmerica in connection with any services performed by TestAmerica or any Results generated from such services, and TestAmerica gives and makes NO OTHER REPRESENTATION OR WARRANTY OF ANY KIND,

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EXPRESS OR IMPLIED. No representative of TestAmerica is authorized to give or make any other representation or warranty or modify this warranty in any way.

4.5 Client's sole and exclusive remedy for the breach of warranty in connection with any services performed by TestAmerica, will be limited to repeating any services performed, contingent on the Client's providing, at the request of TestAmerica and at the Client's expense, additional sample(s) if necessary. Any reanalysis requested by the Client generating Results consistent with the original Results will be at the Client's expense. If resampling is necessary, TestAmerica's liability for resampling costs will be limited to actual cost or one hundred and fifty dollars ($150) per sample, whichever is less.

4.6 TestAmerica's liability for any and all causes of action arising hereunder, whether based in contract, tort, warranty, negligence or otherwise, shall be limited to the lesser amount of compensation for the services performed or $100,000. All claims, including those for negligence, shall be deemed waived unless suit thereon is filed within one year after TestAmerica's completion of the services. Under no circumstances, whether arising in contract, tort (including negligence), or otherwise, shall TestAmerica be responsible for loss of use, loss of profits, or for any special, indirect, incidental or consequential damages occasioned by the services performed or by application or use of the reports prepared.

4.7 In no event shall TestAmerica have any responsibility or liability to the Client for any failure or delay in performance by TestAmerica which results, directly or indirectly, in whole or in part, from any cause or circumstance beyond the reasonable control of TestAmerica. Such causes and circumstances shall include, but not be limited to, acts of God, acts of Client, acts or orders of any governmental authority, strikes or other labor disputes, natural disasters, accidents, wars, civil disturbances, equipment breakdown, matrix interference or unknown highly contaminated samples that impact instrument operation, unavailability of supplies from usual suppliers, difficulties or delays in transportation, mail or delivery services, or any other cause beyond TestAmerica's reasonable control.

5. RESULTS, WORK PRODUCT

5.1 Data or information provided to TestAmerica or generated by services performed under this agreement shall only become the property of the Client upon receipt in full by TestAmerica of payment for the whole Order. Ownership of any analytical method, QA/QC protocols, software programs or equipment developed by TestAmerica for performance of work will be retained by TestAmerica, and Client shall not disclose such information to any third party.

5.2 Data and sample materials provided by Client or at Client’s request, and the result obtained by TestAmerica shall be held in confidence (unless such information is generally available to the public or is in the public domain or Client has failed to pay TestAmerica for all services rendered or is otherwise in breach of these Terms and Conditions), subject to any disclosure required by law or legal process.

5.3 Should the Results delivered by TestAmerica be used by the Client or Client's client, even though subsequently determined not to meet the warranties described in these Terms and Conditions, then the compensation will be adjusted based upon mutual agreement. In no case shall the Client unreasonably withhold TestAmerica's right to independently defend its data.

5.4 TestAmerica reserves the right to perform the services at any laboratory in the TestAmerica network, unless the Client has specified a particular location for the work. In addition, TestAmerica reserves the right to subcontract services ordered by the Client to another laboratory or laboratories, if, in TestAmerica's sole judgment, it is reasonably necessary, appropriate or advisable to do so. TestAmerica will in no way be liable for any subcontracted services (outside the TestAmerica network) except for work performed at laboratories which have been audited and approved by TestAmerica.

5.5 TestAmerica shall dispose of the Client's samples 30 days after the analytical report is issued, unless instructed to store them for an alternate period of time or to return such samples to the Client, in a manner consistent with U.S. Environmental Protection Agency regulations or other applicable federal, state or local requirements. Air samples in Summa canisters will be retained for 5 days after analysis and data review. Longer storage periods may be requested and may be accommodated as space allows for an additional charge. Any samples for projects that are canceled or not accepted, or for which return was requested, will be returned to the Client at his own expense. TestAmerica reserves the right to return to the Client any sample or unused portion of a sample that is not within TestAmerica's permitted capability or the capabilities of TestAmerica's designated waste disposal vendor(s). ALL DIOXIN, MIXED WASTE, AND RADIOACTIVE SAMPLES WILL BE RETURNED TO THE CLIENT, unless prior arrangements for disposal are made.

5.6 Unless a different time period is agreed to in any order under these Terms and Conditions, TestAmerica agrees to retain all records for five (5) years.

5.7 In the event that TestAmerica is required to respond to legal process related to services for Client, Client agrees to reimburse TestAmerica for hourly charges for personnel involved in the response and attorney fees reasonably incurred in obtaining advice concerning the response, preparation to testify, and appearances related to the legal process, travel and all reasonable expenses associated with the litigation.

6. INSURANCE

6.1 TestAmerica shall maintain in force during the performance of services under these Terms and Conditions, Workers' Compensation and Employer's Liability Insurance in accordance with the laws of the states having jurisdiction over TestAmerica's employees who are engaged in the performance of the work. TestAmerica shall also maintain during such period, Comprehensive General and Contractual Liability (limit of $1,000,000 per occurrence/ $2,000,000aggregate), Comprehensive Automobile Liability, owned and hired, ($1,000,000 combined single limit), and Professional/Pollution Liability Insurance (limit of $5,000,000 per occurrence/aggregate).

7. AUDIT

7.1 Upon prior notice to TestAmerica, the Client may audit and inspect TestAmerica's records and accounts covering reimbursable costs related to work done for the Client, for a period of two (2) years after completion of the work. The purpose of any such audit shall be only for verification of such costs, and TestAmerica shall not be required to provide access to cost records where prices are expressed as fixed fees or published unit prices.

8. MISCELLANEOUS PROVISIONS

8.1 These Terms and Conditions, together with any additions or revisions which may be agreed to in writing by TestAmerica, embody the whole agreement of the parties and provide the only remedies available. There are no promises, terms, conditions, understandings, obligations or agreements other than those contained herein, and these Terms and Conditions shall supersede all previous communications, representations, or agreements, either verbal or written, between the Client and TestAmerica. These Terms and Conditions, and any transactions or agreements to which they apply, shall be governed both as to interpretation and performance by the laws of the state where TestAmerica's services are performed.

8.2 The invalidity or unenforceability, in whole or in part of any provision, term or condition hereof shall not affect in any way the validity or enforceability of the remainder to these Terms and Conditions, the intent of the parties being that the provisions be severable. The section headings of these Terms and Conditions are intended solely for convenient reference and shall not define, limit or affect in any way these Terms and Conditions or their interpretations. No waiver by either party of any provision, term or condition hereof or of any obligation of the other party hereunder shall constitute a waiver of any subsequent breach or other obligation.

8.3 The obligations, liabilities, and remedies of the parties, as provided herein, are exclusive and in lieu of any others available at law or in equity. Indemnifications, releases from liability and limitations of liability shall apply, notwithstanding the fault, negligence or strict liability of the party to be indemnified, released, or whose liability is limited, except to the extent of sole negligence or willful misconduct.

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TURNAROUND TIME PRICING

ALKALINITY (CACO3) in WATER

Same Day Rush	1 Day Rush	2 Day Rush	3 Day Rush	5 Day Rush	Standard TAT
$42.00	$28.00	$24.50	$21.00	$14.00	$14.00

CHLORIDE (EPA 300.0) in WATER

Same Day Rush	1 Day Rush	2 Day Rush	3 Day Rush	5 Day Rush	Standard TAT
$42.00	$28.00	$24.50	$21.00	$14.00	$14.00

DIS IRON (200.7) in WATER

Same Day Rush	1 Day Rush	2 Day Rush	3 Day Rush	5 Day Rush	Standard TAT
$29.25	$19.50	$17.06	$14.63	$9.75	$9.75

ICP CALCIUM (200.7) in WATER

Same Day Rush	1 Day Rush	2 Day Rush	3 Day Rush	5 Day Rush	Standard TAT
$29.25	$19.50	$17.06	$14.63	$9.75	$9.75

ICP IRON (200.7) in WATER

Same Day Rush	1 Day Rush	2 Day Rush	3 Day Rush	5 Day Rush	Standard TAT
$29.25	$19.50	$17.06	$14.63	$9.75	$9.75

ICP MAGNESIUM (200.7) in WATER

Same Day Rush	1 Day Rush	2 Day Rush	3 Day Rush	5 Day Rush	Standard TAT
$29.25	$19.50	$17.06	$14.63	$9.75	$9.75

ICP MANGANESE (200.7) in WATER

Same Day Rush	1 Day Rush	2 Day Rush	3 Day Rush	5 Day Rush	Standard TAT
$29.25	$19.50	$17.06	$14.63	$9.75	$9.75

PERCHLORATE (314.0) in WATER

Same Day Rush	1 Day Rush	2 Day Rush	3 Day Rush	5 Day Rush	Standard TAT
$195.00	$130.00	$113.75	$97.50	$65.00	$65.00

SULFATE (EPA 300.0) in WATER

Same Day Rush	1 Day Rush	2 Day Rush	3 Day Rush	5 Day Rush	Standard TAT
$42.00	$28.00	$24.50	$21.00	$14.00	$14.00

VOLATILE ORGANICS (EPA 8260B) in WATER

Same Day Rush	1 Day Rush	2 Day Rush	3 Day Rush	5 Day Rush	Standard TAT
$195.00	$130.00	$113.75	$97.50	$65.00	$65.00

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ANALYTICAL METHOD INFORMATION

ALKALINITY (CACO3) in WATER (SM 2320B)

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	BlankSpike/LCS %R	BlankSpike/LCS RPD
Alkalinity as CaCO3	1.5	6.0 mg/l		20			90 - 110	20
Bicarbonate Alkalinity as CaCO3	6.0	6.0 mg/l		20				
Carbonate Alkalinity as CaCO3	6.0	6.0 mg/l		20				
Hydroxide Alkalinity as CaCO3	6.0	6.0 mg/l		20				
Alkalinity, Phenolphthalein	6.0	6.0 mg/l		20				

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CHLORIDE (EPA 300.0) in WATER (EPA 300.0)

		Reporting Limit	Surrogate	Duplicate	Matrix Spike		BlankSpike/LCS	
Analyte	MDL		%R	RPD	%R	RPD	%R	RPD
Chloride	0.056	2.0 mg/l			80 - 120	15	90 - 110	15

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DIS IRON (200.7) in WATER (EPA 200.7)

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	BlankSpike/LCS %R	BlankSpike/LCS RPD
Iron	0.031	0.050 mg/l			70 - 130	20	85 - 115	20

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ICP CALCIUM (200.7) in WATER (EPA 200.7)

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	BlankSpike/LCS %R	BlankSpike/LCS RPD
Calcium	0.25	2.0 mg/l			70 - 130	20	85 - 115	20

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ICP IRON (200.7) in WATER (EPA 200.7)

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	BlankSpike/LCS %R	BlankSpike/LCS RPD
Iron	0.031	0.050 mg/l			70 - 130	20	85 - 115	20

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ICP MAGNESIUM (200.7) in WATER (EPA 200.7)

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	BlankSpike/LCS %R	BlankSpike/LCS RPD
Magnesium	0.20	2.0 mg/l			70 - 130	20	85 - 115	20

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ICP MANGANESE (200.7) in WATER (EPA 200.7)

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	BlankSpike/LCS %R	BlankSpike/LCS RPD
Manganese	0.0096	0.010 mg/l			70 - 130	20	85 - 115	20

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PERCHLORATE (314.0) in WATER (EPA 314.0)

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	BlankSpike/LCS %R	BlankSpike/LCS RPD
Perchlorate	0.47	2.0 ug/l		15	80 - 120	15	85 - 115	15

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SULFATE (EPA 300.0) in WATER (EPA 300.0)

		Reporting Limit	Surrogate	Duplicate	Matrix Spike		BlankSpike/LCS	
Analyte	MDL		%R	RPD	%R	RPD	%R	RPD
Sulfate	0.091	2.0 mg/l		15	80 - 120	15	90 - 110	15

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VOLATILE ORGANICS (EPA 8260B) in WATER (EPA 8260B)

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	BlankSpike/LCS %R	BlankSpike/LCS RPD
Acetone	7.3	20 ug/l			10 - 150	35	30 - 150	35
Benzene	0.12	1.0 ug/l			70 - 130	20	70 - 130	20
Bromobenzene	0.14	1.0 ug/l			70 - 130	20	70 - 130	20
Bromochloromethane	0.27	1.0 ug/l			70 - 130	20	70 - 130	20
Bromodichloromethane	0.23	1.0 ug/l			70 - 130	20	70 - 130	20
Bromoform	0.37	2.0 ug/l			62 - 126	20	67 - 122	20
Bromomethane	0.67	4.0 ug/l			55 - 136	24	64 - 132	20
2-Butanone (MEK)	2.2	10 ug/l			22 - 150	31	48 - 150	33
n-Butylbenzene	0.21	1.0 ug/l			70 - 130	20	70 - 130	20
sec-Butylbenzene	0.23	1.0 ug/l			70 - 130	20	70 - 130	20
tert-Butylbenzene	0.25	1.0 ug/l			70 - 130	20	70 - 130	20
Carbon disulfide	0.86	5.0 ug/l			56 - 132	20	61 - 126	20
Carbon tetrachloride	0.15	1.0 ug/l			76 - 131	20	70 - 130	20
Chlorobenzene	0.17	1.0 ug/l			70 - 130	20	70 - 130	20
Chloroethane	0.25	4.0 ug/l			67 - 134	20	69 - 128	20
Chloroform	0.13	1.0 ug/l			70 - 130	20	70 - 130	20
Chloromethane	0.21	4.0 ug/l			50 - 135	20	56 - 131	20
2-Chlorotoluene	0.17	1.0 ug/l			70 - 130	20	70 - 130	20
4-Chlorotoluene	0.20	1.0 ug/l			70 - 130	20	70 - 130	20
Dibromochloromethane	0.22	1.0 ug/l			70 - 130	20	70 - 130	20
1,2-Dibromo-3-chloropropane	0.82	2.0 ug/l			60 - 135	29	63 - 129	25
1,2-Dibromoethane (EDB)	0.30	1.0 ug/l			70 - 130	20	70 - 130	20
Dibromomethane	0.26	1.0 ug/l			70 - 130	20	70 - 130	20
1,2-Dichlorobenzene	0.22	1.0 ug/l			70 - 130	20	70 - 130	20
1,3-Dichlorobenzene	0.14	1.0 ug/l			70 - 130	20	70 - 130	20
1,4-Dichlorobenzene	0.17	1.0 ug/l			70 - 130	20	70 - 130	20
Dichlorodifluoromethane	0.15	4.0 ug/l			36 - 150	22	42 - 150	20
1,1-Dichloroethane	0.14	1.0 ug/l			70 - 130	20	70 - 130	20
1,2-Dichloroethane	0.31	1.0 ug/l			68 - 143	20	72 - 133	20
1,1-Dichloroethene	0.23	2.0 ug/l			70 - 130	20	70 - 130	20
cis-1,2-Dichloroethene	0.21	1.0 ug/l			70 - 130	20	70 - 130	20
trans-1,2-Dichloroethene	0.29	1.0 ug/l			70 - 130	20	70 - 130	20
1,2-Dichloropropane	0.23	1.0 ug/l			70 - 130	20	70 - 130	20
1,3-Dichloropropane	0.23	1.0 ug/l			70 - 130	20	70 - 130	20
2,2-Dichloropropane	0.18	1.0 ug/l			66 - 130	20	70 - 130	20
1,1-Dichloropropene	0.20	1.0 ug/l			70 - 130	20	70 - 130	20
cis-1,3-Dichloropropene	0.14	1.0 ug/l			70 - 130	20	70 - 130	20
trans-1,3-Dichloropropene	0.47	1.0 ug/l			71 - 132	20	70 - 130	20
Ethylbenzene	0.32	2.0 ug/l			70 - 130	20	70 - 130	20
Hexachlorobutadiene	0.28	1.0 ug/l			66 - 129	21	70 - 130	20
2-Hexanone	1.5	10 ug/l			18 - 150	25	44 - 150	31
Iodomethane	0.21	2.0 ug/l			47 - 141	29	58 - 138	25
Isopropylbenzene	0.26	1.0 ug/l			78 - 137	20	70 - 130	20
p-Isopropyltoluene	0.21	1.0 ug/l			70 - 130	20	70 - 130	20
Methylene Chloride	0.67	4.0 ug/l			74 - 132	20	70 - 130	20
4-Methyl-2-pentanone (MIBK)	1.3	10 ug/l			56 - 145	26	61 - 142	22
Methyl-tert-butyl Ether (MTBE)	0.22	5.0 ug/l			67 - 138	21	70 - 130	20
Naphthalene	0.51	2.0 ug/l			54 - 135	33	65 - 129	20

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VOLATILE ORGANICS (EPA 8260B) in WATER (EPA 8260B)

Analyte	MDL	Reporting Limit	Surrogate %R	Duplicate RPD	Matrix Spike %R	Matrix Spike RPD	BlankSpike/LCS %R	BlankSpike/LCS RPD
n-Propylbenzene	0.21	1.0 ug/l			70 - 130	20	70 - 130	20
Styrene	0.17	1.0 ug/l			51 - 123	21	70 - 130	20
1,1,1,2-Tetrachloroethane	0.35	1.0 ug/l			70 - 130	20	70 - 130	20
1,1,2,2-Tetrachloroethane	0.33	2.0 ug/l			69 - 133	20	70 - 130	20
Tetrachloroethene	0.18	1.0 ug/l			70 - 130	20	70 - 130	20
Toluene	0.28	2.0 ug/l			70 - 130	20	70 - 130	20
1,2,3-Trichlorobenzene	0.45	1.0 ug/l			70 - 130	20	70 - 130	20
1,2,4-Trichlorobenzene	0.32	1.0 ug/l			66 - 126	20	70 - 130	20
1,1,1-Trichloroethane	0.15	1.0 ug/l			76 - 132	20	70 - 130	20
1,1,2-Trichloroethane	0.31	1.0 ug/l			70 - 130	20	70 - 130	20
Trichloroethene	0.24	1.0 ug/l			70 - 130	20	70 - 130	20
Trichlorofluoromethane	0.15	4.0 ug/l			74 - 150	20	78 - 149	20
1,2,3-Trichloropropane	0.78	1.0 ug/l			70 - 130	20	70 - 130	20
1,2,4-Trimethylbenzene	0.25	1.0 ug/l			70 - 130	20	70 - 130	20
1,3,5-Trimethylbenzene	0.21	1.0 ug/l			61 - 138	33	70 - 130	20
Vinyl Acetate	0.81	5.0 ug/l			50 - 150	23	57 - 149	21
Vinyl chloride	0.18	1.0 ug/l			58 - 139	21	66 - 134	20
Xylenes, Total	0.86	3.0 ug/l			70 - 130	20	70 - 130	20
*1,3-Butadiene	0.14	2.0 ug/l			70 - 130	20	7 - 130	20
*n-Hexane	1.6	2.0 ug/l			70 - 130	20	70 - 130	20
Sur: Dibromofluoromethane			70 - 130					
Sur: Toluene-d8			70 - 130					
Sur: 4-Bromofluorobenzene			70 - 130					
*o-Xylene	0.42	1.0 ug/l				20		20
*m,p-Xylenes	0.44	2.0 ug/l				20		20

* - Analyte not a part of normal reporting list. Special request only.

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Phoenix, AZ 85040
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ANALYTICAL METHOD INFORMATION FOR GROUP ANALYSES

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A. Analytical Report
B. Chain of Custody (COC) Form
C. Method Blank
D. Matrix Spike / Matrix Spike Duplicate Summary (MS/MSD)
E. LCS
F. Report Detection Limits Listed on All Reports
G. Case Narrative
H. Corrective Action Reports when necessary

Level III. Tertiary Data Package Provided Upon Request

A. All QC Data Included In Levels I and II plus
B. MS/MSD analysis performed on specific sample upon request
C. Chromatograms, including QC and Samples
D. Quantitation reports
E. Initial and Continuing Calibration Information
F. Analysis Logs
G. Extraction / Preparation Logs

Level IV. Quaternary Data Package Provided Upon Request
(CLP-TYPE Validation package)

A. All QC Data Included In Levels I, II, and III plus:
B. Multiple Sample Dilutions Reported
C. Initial and Continuing Calibration Chromatograms and Quantitaion Reports
D. Standard Preparation Log

Electronic Data Deliverables available upon request.

D2 – Alternative 2
In-Well Stripping + Hydraulic Barrier

TABLE D2
Feasibility Screening Results
Phoenix-Goodyear Airport-North Superfund Site
Goodyear, Arizona

ESTIMATE OF PROBABLE COST
In-well Air-stripping + Hydraulic Barrier (Alternative 2)

NO.	ITEM	ESTIMATED QTY RANGE	UNIT (EA, LF, LS)	UNIT PRICE RANGE	ESTIMATED COST RANGE	COST SOURCE
1.00	**Permits, Design, and Work Plan**					
1.01	Health & Safety Plan	1 - 1	LS	$10,000 - $10,000	$10,000 - $10,000	Estimate from other sites
1.02	Pilot test	1 - 1	LS	$200,500 - $267,300	$200,500 - $267,300	Quote in D-2
1.03	Permits, design, office support	1 - 1	LS	$80,062 - $80,062	$80,062 - $80,062	Estimate from other sites
1.04	Work Plan and Report	1 - 1	LS	$69,233 - $69,233	$69,233 - $69,233	Estimate from other sites
				Permits, Design, and Work Plan Subtotal:	***$359,800 - $426,600***	
2.00	**Full Scale Mobilization/Demobilization**					
2.01	Fencing	5 - 5	LS	$2,300 - $2,300	$11,500 - $11,500	Quote in D-1
2.02	Aboveground piping installation from MTS	4,865 - 4,865	FT	$7 - $10	$34,055 - $48,650	Estimate from other sites
2.03	Tank rental and misc equipment	1 - 1	MO	$3,000 - $5,000	$3,000 - $5,000	Quote in D-1
				Full Scale Mobilization/Demobilization Subtotal:	***$48,600 - $65,200***	
3.00	**Well Installation, System Set-up**					
3.01	Survey	1 - 2	DAY	$1,000 - $1,000	$1,000 - $2,000	Estimate from other sites
3.02	Driller installation of recirculation wells, piezometers, mob/demob	1 - 1	LS	$1,768,884 - $1,768,884	$1,768,884 - $1,768,884	Quote in D-1
3.03	Driller installation of monitoring wells, mob/demob	12 - 12	WELL	$16,050 - $16,050	$192,600 - $192,600	Quote in D-1
3.04	Subcontractor design, equipment, equipment install-recirculation wells	17 - 17	WELL	$94,243 - $94,243	$1,602,131 - $1,602,131	Quote in D-2
3.05	Subcontractor installation of soil vapor collection and control system	1 - 1	LS	$300,000 - $300,000	$300,000 - $300,000	Estimate from other sites
3.06	Electrical Contractor	3 - 4	WK	$15,000 - $15,000	$45,000 - $60,000	Estimate from other sites
3.07	Solid waste disposal	39 - 39	BIN	$500 - $750	$19,500 - $29,250	Quote in D-1
3.08	Analytical lab, hydropunch samples, 24-hr TAT	101 - 101	SAMPLE	$240 - $240	$24,240 - $24,240	Quote in D-1
3.09	Sieve analyses	34 - 34	WELL	$91 - $91	$3,094 - $3,094	Estimate from other sites
3.10	Connection to MTS for provision of treated water to source area	1 - 1	LS	$75,000 - $75,000	$75,000 - $75,000	Estimate from other sites
3.11	Oversight	1 - 1	LS	$84,418 - $84,418	$84,418 - $84,418	Estimate from other sites
3.12	Pumping test	1 - 1	LS	$18,700 - $18,700	$18,700 - $18,700	Quote in D-1
3.13	Baseline sampling (lab costs only)	35 - 35	SAMPLE	$238 - $238	$8,330 - $8,330	Quote in D-1
3.14	Reporting and meetings	1 - 1	LS	$62,168 - $62,168	$62,168 - $62,168	Estimate from other sites
				Well Installation, System Set-up Subtotal:	***$4,205,100 - $4,230,800***	
4.00	**Year 1 Activities**					
4.01	Sampling	4 - 4	EVENT	$10,000 - $12,000	$40,000 - $48,000	Estimate from other sites
4.02	Analytical suite (standard TAT)	140 - 140	SAMPLE	$238 - $238	$33,320 - $33,320	Quote in D-1
4.03	Data validation	4 - 4	LS	$5,000 - $5,000	$20,000 - $20,000	Estimate from other sites
4.04	Reporting and meetings	1 - 1	LS	$62,168 - $62,168	$62,168 - $62,168	Estimate from other sites
4.05	Electricity	17 - 17	WELL	$400 - $500	$6,800 - $8,500	Estimate from other sites
4.06	Maintenance (labor for O&M)	36 - 50	DAY	$300 - $350	$10,800 - $17,500	Estimate from other sites
				Year 1 Activities Subtotal:	***$173,100 - $189,500***	
5.00	**Year 2 Activities**					
5.01	Sampling	4 - 4	EVENT	$10,000 - $12,000	$40,000 - $48,000	Estimate from other sites
5.02	Analytical suite (standard TAT)	70 - 70	SAMPLE	$238 - $238	$16,660 - $16,660	Quote in D-1
5.03	Data validation	2 - 2	LS	$5,000 - $5,000	$10,000 - $10,000	Estimate from other sites
5.04	Reporting and meetings	1 - 1	LS	$62,168 - $62,168	$62,168 - $62,168	Estimate from other sites
5.05	Electricity	17 - 17	WELL	$450 - $600	$7,650 - $10,200	Estimate from other sites
5.06	Maintenance (labor for O&M)	36 - 50	DAY	$300 - $350	$10,800 - $17,500	Estimate from other sites
				Year 2 Activities Subtotal:	***$147,300 - $164,500***	

TABLE D2
Feasibility Screening Results
Phoenix-Goodyear Airport-North Superfund Site
Goodyear, Arizona

ESTIMATE OF PROBABLE COST
In-well Air-stripping + Hydraulic Barrier (Alternative 2)

NO.	ITEM	ESTIMATED QTY RANGE	UNIT (EA, LF, LS)	UNIT PRICE RANGE	ESTIMATED COST RANGE	COST SOURCE
6.00	**Year 3 Activities**					
6.01	Sampling	4 - 4	EVENT	$10,000 - $12,000	$40,000 - $48,000	Estimate from other sites
6.02	Analytical suite (standard TAT)	70 - 70	SAMPLE	$238 - $238	$16,660 - $16,660	Quote in D-1
6.03	Data validation	2 - 2	LS	$5,000 - $5,000	$10,000 - $10,000	Estimate from other sites
6.04	Reporting and meetings	1 - 1	LS	$62,168 - $62,168	$62,168 - $62,168	Estimate from other sites
6.05	Electricity	17 - 17	WELL	$500 - $650	$8,500 - $11,050	Estimate from other sites
6.06	Maintenance (labor for O&M)	36 - 50	DAY	$300 - $350	$10,800 - $17,500	Estimate from other sites
				Year 3 Activities Subtotal:	***$148,100 - $165,400***	
7.00	**Year 4 - 20 O&M Activities**					
7.01	Sampling	2 - 2	EVENT	$10,000 - $12,000	$20,000 - $24,000	Estimate from other sites
7.02	Analytical suite (standard TAT)	35 - 35	SAMPLE	$257 - $257	$8,995 - $8,995	Quote in D-1
7.03	Data validation	1 - 1	LS	$5,000 - $5,000	$5,000 - $5,000	Estimate from other sites
7.04	Reporting and meetings	35 - 35	SAMPLE	$257 - $257	$8,995 - $8,995	Estimate from other sites
7.05	Electricity	17 - 17	WELL	$550 - $700	$9,350 - $11,900	Estimate from other sites
7.06	Maintenance (labor for O&M)	36 - 50	DAY	$300 - $350	$10,800 - $17,500	Estimate from other sites
7.07	Equipment maintenance & replacement	1 - 1	YEAR	$8,844 - $17,689	$8,844 - $17,689	Estimate from other sites
				r 4 - 20 O&M Activities Subtotal:	$72,000 $94,100	
				NPV for O&M:	***$1,332,600 $1,741,600***	
8.00	**Closure Costs**					
8.01	Abandon recirculation wells, piezometers	17 - 17	WELL	$1,850 - $2,565	$31,450 - $43,605	Quote in D-1
8.02	Abandon groundwater wells	12 - 12	WELL	$1,760 - $2,475	$21,120 - $29,700	Quote in D-1
8.03	Solid waste disposal	15 - 30	BIN	$500 - $750	$7,500 - $22,500	Quote in D-1
8.04	Demob treatment system	1 - 1	LS	$20,000 - $20,000	$20,000 - $20,000	Estimate from other sites
8.05	Abandon/remove collection system	1 - 1	LS	$50,000 - $50,000	$50,000 - $50,000	Estimate from other sites
8.06	Site restoration	1 - 1	LS	$25,000 - $50,000	$25,000 - $50,000	Estimate from other sites
8.07	Oversight	2 - 3	MO	$120,000 - $120,000	$240,000 - $360,000	Estimate from other sites
8.08	Reporting and meetings	1 - 1	LS	$60,000 - $100,000	$60,000 - $100,000	Estimate from other sites
			CAPITAL COST SUBTOTAL (TASKS 1-6):		**$5,082,000 $5,242,000**	
			O&M COST SUBTOTAL (TASK 7):		**$1,332,600 $1,741,600**	
			CLOSURE COST SUBTOTAL (TASK 8):		**$455,070 $675,805**	
	TOTAL COST (BARE):				**$6,869,670 $7,659,405**	
		AVERAGE COST (BARE):			**$7,264,538**	
	TOTAL COST WITH -30% TO +50% CONTINGENCY:				**$5,085,200 $10,896,800**	

Nov 10, 2011

Via Email: ctsiatsios@HaleyAldrich.com

Christopher J. Tsiatsios, P.E.
Engineer
HALEY & ALDRICH, INC.
3187 Red Hill Avenue, Suite 155
Costa Mesa, CA 92626
Office: 714.371.1820
Cell: 714.920.1593
Fax: 714.371.1870

Subject: Treatment of cVOCs in Groundwater using mGCW Technology
Phoenix- Goodyear Airport-North Superfund Site, Goodyear, AZ
Adventus Proposal No. AAI11-677

Dear Mr. Tsiatsios:

Please find herewith a conceptual design, list of assumptions, data gaps, scope of work, and a cost estimate to provide Groundwater Circulation Well (GCW) Technology for the treatment of chlorinated solvents in groundwater at the above referenced site. Our review of the site-specific information which you provided suggests that a variation of our modified groundwater circulation well (mGCW) technology (http://www.adventus.us/mgcw.htm) will be effective at this site.

1. DESCRIPTION OF mGCW TECHNOLOGY

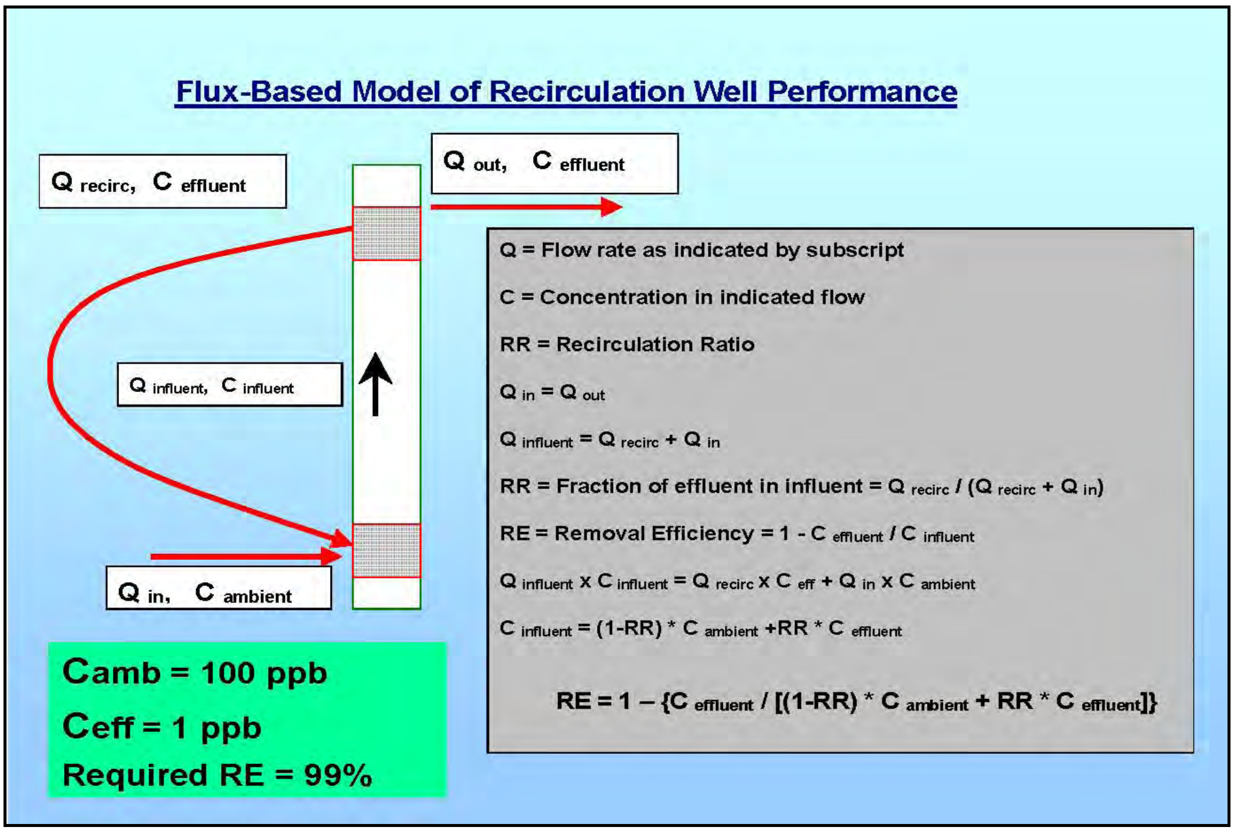
Groundwater circulation well systems are designed to create *in situ* vertical groundwater circulation cells by drawing groundwater from an aquifer through one screen section of a multi-screened well and discharging it through another screen section. Groundwater circulation commonly occurs from the top of the formation to the bottom (herein termed "standard flow"). Under standard flow conditions, groundwater is pumped upward inside the remediation well as it enters a lower screen section and exits an upper screen section. Groundwater flow upward through the mGCW can be achieved via an airlift effect, or it can be induced via a submersible, in-well groundwater circulation pump. The circulation cell flow path thus encompasses groundwater flowing from the upper part of the treatment zone into the lower part.

In a reverse circulation mode, the flow of groundwater within the mGCW well is downward via the aid of an in-well groundwater pump (*i.e.,* water flows from the bottom of the aquifer formation in a torroidal upward pattern). In the reverse circulation mode, water in the lower half of the aquifer moves away from the well, while water in the upper half of the aquifer moves toward the well.

In both the standard and reverse flow modes of operation, groundwater is circulated around the central mGCW, but none is removed from the aquifer. Induced differences in potentiometric head establish and maintain the 3-dimensional circulation cell in an ellipsoidal area around the circulation well. The majority of the groundwater captured by the circulation cell circulates a number of times through the mGCW before being released downgradient. As such, water serves as the *in situ* carrier bringing constituents of interest (COI) from throughout the capture zone to the mGCW system where it is treated and then discharged back into the formation. This method of vertical and horizontal circulation flow patterns force water to move through the entire aquifer portion within the circulation cell thus improving COI mobilization by forcing flow through less permeable formation lenses. Similarly, amendments such as nutrients and organic substrates can be distributed quickly at greater depths and over a larger area by using mGCW.

With natural groundwater flow, the total amount of water circulating around an mGCW will consist of: a) upgradient water being captured, and b) groundwater being recirculated. The relationship of a:b varies based on the aquifer parameters. A typical example of a:b relationship is 15:85. Thus, of the total volume of groundwater being circulated in the cell at any time, 15% represents upgradient, potentially impacted water. An equal portion of groundwater will exit the circulation cell in the downgradient release zone following treatment. These flow dynamics and dimensions of the capture zone, circulation cell, and release zone can be calculated for a specific site and used as design aids based on numerical simulations of the groundwater hydraulics (**Figure 1**). However, site-specific calibration of the modeled value should be conducted prior to the final design and engineering of a remedial system composed of multiple, overlapping mGCW systems. **Figure 1** shows that contaminants are treated as groundwater passes through the mGCW. In well treatment is not considered in the application proposed for this site. The mGCW will facilitate the distribution of nutrients and amendments to promote biodegradation of the COI in the aquifer.

Figure 1. General Flow Schematic of a Standard-Flow mGCW-Type System.



The applicable treatment components of the mGCW at this site are:

- o *In situ* soil flushing: Movement of groundwater in a circular mode is realized through vertical groundwater circulation. The circulating groundwater constantly flushes contaminants sorbed to the soil particles and makes them available for treatment in the aqueous phase.

o Enhanced Anaerobic Biodegradation: The mGCW will deliver organic substrates, inorganic nutrients and hydrogen (all breakdown products of EHC) within the contaminated zone to promote abiotic and biotic degradation of COI.

POTENTIAL ADVANTAGES OF mGCW TECHNOLOGY

Our experiences from installing hundreds of mGCW systems at multiple sites throughout the world suggest that this technology is well suited to the Site conditions. The proposed technology uniquely offers the following potential advantages:

- Immediate containment of dissolved phase plume constituents;
- Effective *in situ* treatment without groundwater removal from the subsurface;
- Only mGCW technology that can operate effectively under confined aquifer conditions;
- **Only mGCW technology that can operate in a reverse-flow mode;**
- Simultaneous *in situ* treatment of capillary fringe and groundwater;
- Minimally invasive and non-disruptive to Site conditions;
- Enhanced groundwater treatment due to the ability of the mGCW system to create vertical and horizontal components of groundwater flow;
- Enhances natural attenuation processes for more rapid treatment of downgradient plume COI;
- Very low energy requirements;
- Low operation and monitoring requirements
- **Demonstrated effectiveness at over 800 related sites**; and
- More cost-efficient treatment when compared to conventional pump-and-treat.

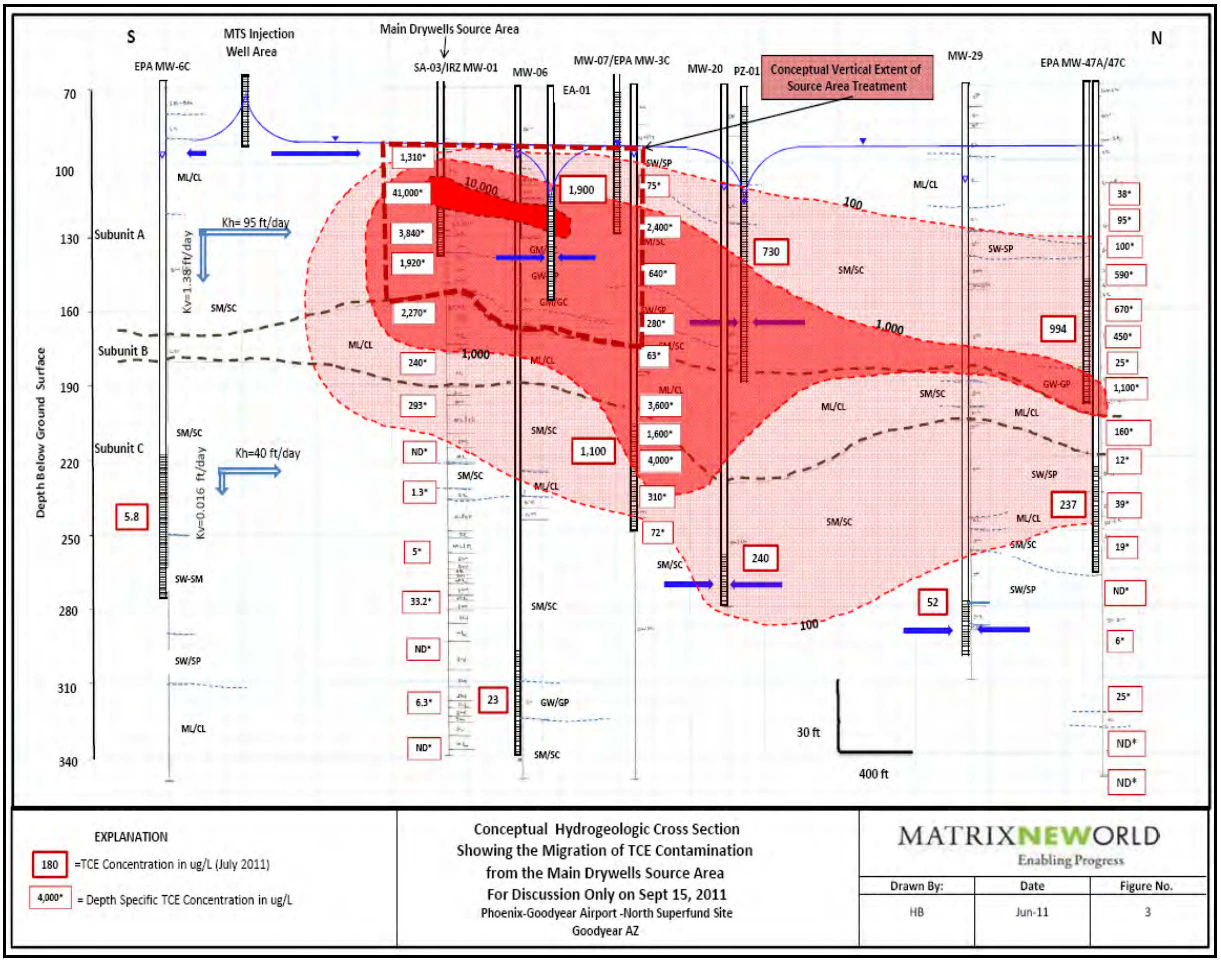
2. UNDERSTANDING SITE CONDITIONS AND GOALS

The site is located in the town of Goodyear, AZ. The primary constituent of interest (COI) at the site is TCE. The sources of TCE plume are Dry Well locations at the site from historic manufacturing activities. The TCE plume has migrated north from the dry wells beyond the property boundary. In-situ treatment via the use of mGCW technology is one of the alternatives being evaluated for the source area. **Figure 2** shows the plan view of the site including the dry wells.

Figure 2: Site Map and TCE Study Area

Figure 3 shows a cross section of the plume as it migrates south–north. GCW technology is proposed in the source area (greater than 10 ppm TCE contour) between MW-01 and EA-01. The source area is approximately 250 ft wide and 700 ft long.

Figure 3: TCE Plume Cross Section Map



Depth to groundwater is 90 ft bgs. The targeted vertical treatment zone is from 90 ft bgs to 150 ft bgs (60 ft thick). This zone is in the geologic layer described as Subunit A, which primarily consists of silty sand and gravel.

3. PRELIMINARY REMEDIAL DESIGN – DOWNGRADIENT AREA

The objectives are to reduce the mass of TCE in the source area using GCW technology. The following assumptions have been made to design a preliminary GCW system, and to provide equipment details and associated costs:

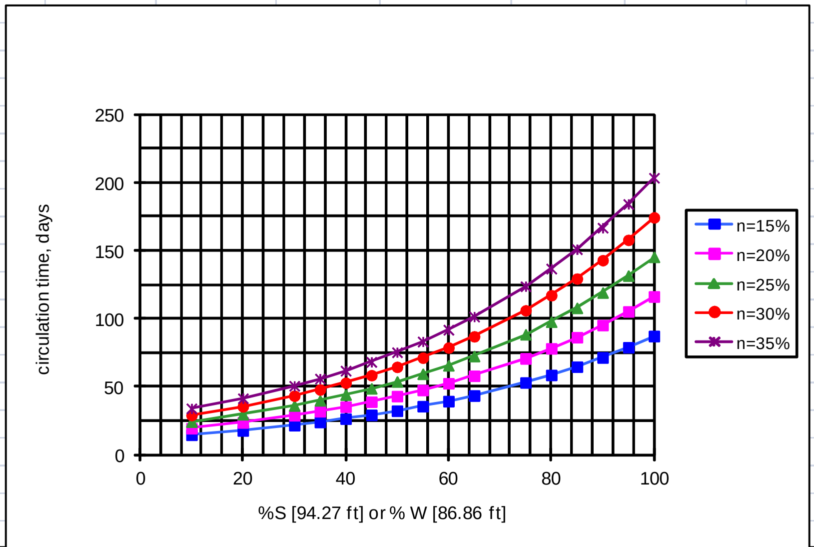
1. Depth to groundwater is 90 ft bgs.
2. Targeted vertical treatment zone is 60 ft thick (from 90 to 150 ft bgs).
3. Width of the plume is 250 ft. Length of the plume is 700 ft
4. Maximum TCE concentration in groundwater is 10,000 ug/L.
5. Horizontal hydraulic conductivity is 95 ft/day
6. Vertical hydraulic conductivity is 1.4 ft/day
7. Porosity is 0.25
8. Horizontal hydraulic gradient is 0.006 ft/ft
9. A minimum recirculation flow rate of 75 gpm can be sustained.
10. The GCW extraction screen will be 15 ft long (from 135 to 150 ft bgs). The GCW injection screen will be 15 ft long (from 90 to 105 ft bgs).

3.1 Preliminary GCW Parameters

On the basis of above assumptions, it is estimated that the groundwater circulation cell will have a radius of influence (ROI) of 87 ft. Since the width of the plume is 250 ft and the length is 700 ft, a total of six GCWs are required (three rows of GCWs, two GCWs in each row) to capture the targeted source area.

The recirculation ratio (ratio of water captured from upgradient to recirculation water) will be 45%. Time for one pore volume flush through the ROI is estimated at 150 days. **Figure 4** shows calculations of GCW parameters.

Site:	Fig. 4 Goodyear Site, AZ - AAI11-677, Kh:Kv=10	
Gradient	0.006	m/m
KH	3.35E-04	m/s
KV	3.35E-05	m/s
v	2.0121E-06	m/s
n	25	%
H	18.288	m
Well Data:		
aT	4.57	m
aB	4.57	m
Q	17.01	m3/hr
a/H	0.25	
Q/(H2KH)	0.04	
Q/(H2v)	7.02	
Qr	7.65	m3/hr
Recirc Ratio	44.98	%



		In Metric Units				In English Units			
KH/Kv = 10		a/H = 0.1	a/H = 0.25	a/H = 0.4		a/H = 0.1	a/H = 0.25	a/H = 0.4	
Stagnation Point	S	30.91	28.73	25.08	m	101.42	94.27	82.30	ft
Maximum Spacing	D	61.08	57.42	51.00	m	200.40	188.40	167.34	ft
Capture Zone Top Width	Bt	11.41	8.06	3.72	m	37.44	26.43	12.20	ft
Capture Zone Bottom Width	Bb	101.94	97.83	90.05	m	334.47	320.99	295.44	ft
W Factor	Bb+Bt/4	28.34	26.47	23.44	m	92.98	86.86	76.91	ft
Captured Flow	Qo	9.87	9.36	8.38	m3/h	43.44	41.21	36.90	gpm
Capture Zone Area	A	1376.46	1312.11	1175.22	m2	14810.70	14118.28	12645.31	ft2

3.2 Preliminary GCW Components

Each GCW system will have the following components:

1. A 12-inch inside diameter GCW well, drilled by appropriate drilling methods to a depth of 150 ft bgs. The well will be constructed of PVC casing and stainless steel screens. The screens will be Johnsons, wire wrapped with a slot size of 20. Each screen will be 15 ft long.
2. A 12-inch inflatable packer to isolate the two screens.
3. A 4-inch submersible pump (Grundfos or equivalent) rated to deliver 75 gpm at 100 ft of water head.
4. A shallow tray or compact air stripper rated to treat 75 gpm, of 10 ppm influent TCE with> 90 % removal efficiency.
5. A blower for the air stripper.
6. A sump pump to inject treated water back to the GCW.
7. A sub-surface vault to house the air stripper.

8. An aboveground shed to house the blower, granular activated carbon (GAC) for vapor treatment and control panel.
9. Miscellaneous instruments (analog flow meter/totalizer, vacuum and pressure gauges, level sensors etc.)

3.3 Data Gaps

Chemical and biological fouling of the well screens and the air stripper trays may reduce the performance and increase operation and maintenance. To evaluate the potential for fouling, two groundwater samples must be collected and analyzed for the parameters listed below.

Field Measurements	Anions	Cations
pH	chloride	dissolved iron
dissolved oxygen	bicarbonate	total iron
conductivity	sulfate	manganese
temperature	calcium	
ORP	magnesium	

In addition to groundwater data gaps, sieve analysis of soil cores from the targeted screen intervals will be required to correctly size and specify the screen slot size and sand pack.

A pumping test (pilot test of GW hydraulics) is highly recommended in one full-scale GCW to understand the circulation cell dynamics. This is typically done without the treatment system for a period of one week with pressure transducers in piezometers.

4. COST ESTIMATE

A budgetary cost estimate for a single mGCW system is provided in Table 3. The extended cost for six (6) GCW systems is **$ 491,700**. This cost includes mGCW equipment and components delivered to the site along with our engineering design and field support. Equipment to be provided in this estimate for each mGCW includes one submersible pump, one inflatable packer, one sump pump, one air stripper including blower, a control panel and associated piping and instrumentation.

Costs excluded from this estimate are:

- Drilling, developing and construction of the GCW.
- Installation of at least two nested piezometers (deep and shallow) for each GCW. These are used to measure the ROI of GCW.
- Sub-surface concrete vault to house, above ground shed, trenching for pipes and electrical conduits
- Vapor treatment system (GAC), and
- Electrical Power
- Cost for a drilling company to install in-well components and connections to above ground shed.

In addition, the cost for conducting one pilot test (two weeks on-site) will be an additional $ 24,000 after the GCW well has been drilled and the in-well and above-ground components have been installed. This cost covers the time to conduct the test and rent pressure transducers and other equipment and to prepare a report.

Table 3. Preliminary Cost Estimate for mGCW Equipment (per well)

mGCW Equipment	Pump, packer, instrumentation, piping, control panel, and air stripper	$ 64,450
	Delivery	$ 4,000
Equipment Total		**$ 68,450**
AAI Labor	Design support	$ 5,500
AAI Labor	Installation and start-up support	$ 8,000
Labor Total*		**$ 13,500**
TOTAL	**per mGCW**	**$ 81,950**
Pilot Test	Rent pressure transducer and conduct a 2-week pilot test including a pilot test report	**$ 24,000**

DISTRIBUTION OF FUTURE RESPONSIBILITIES

For field work at the Site, Adventus will provide environmental biotechnology and design support. It is our intention and understanding that Haley&Aldrich will serve as Project Manager. The distribution of responsibilities envisioned is as follows:

1. Adventus will provide and arrange delivery of listed mGCW components to the Site.
2. Haley&Aldrich will be responsible for contracting drilling and other sub-contractors to support installation of the equipment as necessary. This will include all construction and electrical work, permitting, etc.
3. Adventus personnel will NOT be on site during the drilling of wells.
4. If approved, Adventus will conduct the mGCW pilot test and prepare a test report.
5. Adventus will provide data interpretation and technical writing support, as requested (not budgeted).
6. Haley&Aldrich will provide manpower for receiving shipments, monitoring treatment performance and collecting samples.
7. Haley&Aldrich will be responsible for all sampling and analytical costs along with all data management and reporting costs. Adventus will be responsible for the generation of a pilot test report.
8. Haley&Aldrich will maintain overall project responsibility, and will maintain all client contact and control of the Site.
9. Haley&Aldrich will be responsible for all health and safety, permitting and approvals, sampling and analytical costs along with all data management and reporting costs.

On behalf of Adventus, I thank you for your interest in our products and technologies. Please contact me by telephone at (908) 688-8543 or email at fayaz.lakhwala@adventusgroup.com if you have any questions regarding this proposal.

Yours truly,

Adventus Americas Inc.

Via e-mail

Fayaz Lakhwala, Ph.D.

Director / Remedial Design and Engineering Services

CC: Chris Mullen, Jim Mueller – Adventus Illinois

YELLOW JACKET
DRILLING SERVICES

The Southwest's Premier Provider of Innovative Drilling and Well Services

Mr. Eric Pigati
Haley & Aldrich, Inc
600 S Meyer Ave, Suite 100
Tucson, AZ 85701

Date: 12/2/11
Bid # (A)BB 10-1278

Subject:

Well Pumping & Testing Services -- PGA North, Goodyear, Arizona

Scope of Work:

Utilizing a Smeal 4T Smeal Develpoment / Pump Rig & Support Equipment:
Daily Services for 24 Hour Well Pumping Test - 12' dia well x 25gpm for 24 hours
IDW - All purge & decon to be managed onsite by others / Client to provided tanks, off site disposal, etc
* Client to provide Transducers and any other downhole instrumentation

Item	Quantity	Unit	Cost	Price
DRILLING COSTS				
4T Smeal Development / Pump Rig Equipment; Call-out	1	LS	$ 500.00	$ 500.00
Site Security Clearance, On-Site Training, Safety Meetings..	0	HR	$ 200.00	$ -
Service Hours - Push/Pull Pump, Set up equipment, etc	5	HR	$ 225.00	$ 1,125.00
Service Hours - Perform 24 hour Pump Test	10	HR	$ 225.00	$ 2,250.00
Service Hours - Perform 24 hour Pump Test - night shift (1 man)	13	HR	$ 85.00	$ 1,105.00
4T Smeal Pump Rig Standby ('Client' Directed Work Stoppage..)	0	HR	$ 225.00	$ -
Equipment Rental - Pump, discharge, generator, fuel, etc	2	DY	$ 500.00	$ 1,000.00
55 gal DOT Drums (Estimate - charged for actual useage)	0	EA	$ 50.00	$ -
Service Trailer w/ Water Tank, etc	0	EA	Incl.	Incl.
				$ -
			Estimated Project Total:	**$ 5,980.00**

'YJD' Proposal Assumptions & Conditions:

1.) 'Client' to provide all Local, State, Federal project specific permits.
2.) All drilling locations are to be clear of any and all overhead & subsurface utilities.
3.) All drilling locations are accessible by way of 2-wheel drive truck mounted drilling & related equipment.
4.) All drill cuttings & fluids generated will be stockpiled at the drilling locations.
5.) All drill cuttings & fluids will be placed for storage within 100' of the working area. Containment beyond a distance of 100' will require the use of a forklift and/or loader.
6.) Profiling and disposal of all drill cuttings & fluids generated will be the responsibility of the 'Client'.
7.) An equipped 'Client' arranged/approved on-site water supply source will be made available during all drilling and related phases of the project.
8.) In the event that down-hole tooling (augers, drill pipe, drill collars, stabilizers, adaptor subs, down-hole hammers,

drill bits..) is lost in the process of drilling in adverse ground conditions; 'Client' will reimburse 'YJD' for the replacement of the tooling at current replacement cost.
9.) In the event that sampling equipment (split-spoon, simulprobe, hydro punch..) is lost or damaged in the process of sampling in adverse ground conditions; 'Client' will reimburse 'YJD' for the replacement of the equipment at current replacement cost.
10.) Schedule/Pricing is based on a single rig operation; utilizing one (1) crew, working +/- 10/hour shifts, working a 10/on (Days) 4/off (Days) work schedule (Including Mob/Demob/Travel Time).
11.) Project is not subject to surcharges for Union/Davis Bacon/Prevailing labor rates.
12.) Drill rig standby due to unreadiness of the drilling locations or 'Client' delays will be billed at the provided hourly rate.
13.) If the project encounters difficulties beyond our control or if the scope of work is altered, 'YJD' reserves the right to renegotiate the price.
14.) Materials; due to the market price fluctuations of steel and petroleum based products; 'YJD' cannot guarantee the price of the materials required to complete the project beyond a period of 10-working days from the date in which the pricing is provided. In the event that a material price increase occurs; 'YJD' reserves the right to pass on the difference in the form of a revised proposal or by using the change order process.
15.) This proposal is valid for (60) days from the above date.

All services rendered will be billed promptly upon completion of work. Terms are net **thirty (30) days** unless otherwise agreed in writing in advance. A delinquency charge of 1.5% per month will apply to all past due invoices, unless a lower rate is required by law. Client agrees to pay all court costs and attorneys fees, should court proceedings be initiated or attorneys be retained to collect past due amounts.

We at Yellow Jacket Drilling Services thank you for the opportunity to provide this proposal. If you have any questions, or if we can be of any further assistance please do not hesitate to contact us at (602) 453-3252. We look forward to hearing from you soon.

Sincerely,
Yellow Jacket Drilling Services, LLC

A. Beau Burgess

A. Beau Burgess
Project Manager

Acceptance of all outlined pricing, terms and conditions:

Company Name:________________________________

Authorized Representative (Name & Title):____

Signature:________________________________

The Southwest's Premier Provider of Innovative Drilling and Well Services

Ms. Laura Davis
Haley & Aldrich
600 S. Meyer Avenue, Suite 100
Tucson, AZ 85701-2554

Date: 11/21/11
Bid # (A)JT11-1253

Subject:

Drilling Services -- Phoenix-Goodyear Airport-North, Goodyear, AZ

Scope of Work:

Utilizing a Foremost DR24HD (Dual Rotary 'DR') drill rig:
Drill and install seventeen (17) 12" 304 SS / SCH. 80 PVC circulation wells to a depth of 150' (90'-150', attempt/collect Simulprobe soil/water samples every 20' / 0'-TD, collect bulk samples from cyclone discharge every 5').
*Note: Well construction will be as outlined in 'Client' provided RFP dated 11/15/11.

Utilizing a Speedstar 50K (Air Rotary Casing Hammer 'ARCH') drill rig:
Drill and install nine (9) 1" SCH. 80 PVC nested piezometer wells to a depth of 105'/150' (collect bulk samples from cyclone discharge every 5').
*Note: Well construction will be as outlined in 'Client' provided RFP dated 11/15/11.

Item	Quantity	Unit	Cost	Price
DRILLING COSTS - Circulation Wells				
DR24HD Drilling Equipment; Mob/Demob	1	LS	$ 5,000.00	$ 5,000.00
Site Security Clearance, On-Site Training, Tail Gate Meetings..	0	HR	$ 750.00	$ -
Borehole Clearance; Hand Auger to 5' or Refusal	0	HR	$ 750.00	$ -
Drill 18" (DR) Borehole, 0'-150'	2550	FT	$ 170.00	$ 433,500.00
Attempt/Collect Simulprobe Soil/Water Sample	51	EA	$ 4,150.00	$ 211,650.00
Backfill and/or Construct 12" Well	2550	FT	$ 220.00	$ 561,000.00
36" x 36" x 24" Flush Grade Steel Surface Completion	17	EA	$ 2,500.00	$ 42,500.00
DR24HD Drill Rig Move-on, Set-up, Take-down, Decon..	17	EA	$ 5,000.00	$ 85,000.00
DR24HD Drill Rig Standby ('Client' Directed Work Stoppage..)	6	HR	$ 750.00	$ 4,500.00
Subtotal				**$ 1,343,150.00**

Item	Quantity	Unit	Cost	Price
DRILLING COSTS - Piezometer Wells				
50K Drilling Equipment; Mob/Demob	1	LS	$ 2,250.00	$ 2,250.00
Site Security Clearance, On-Site Training, Tail Gate Meetings..	0	HR	$ 450.00	$ -
Borehole Clearance; Hand Auger to 5' or Refusal	0	HR	$ 450.00	$ -
Drill 7 5/8" (ARCH) Borehole, 0'-150'	1350	FT	$ 35.00	$ 47,250.00
Backfill and/or Construct 1" Nested Well	1350	FT	$ 55.00	$ 74,250.00
12" Flush Grade Steel Surface Completion	9	EA	$ 500.00	$ 4,500.00
50K Drill Rig Move-on, Set-up, Take-down, Decon..	9	EA	$ 900.00	$ 8,100.00
50K Drill Rig Standby ('Client' Directed Work Stoppage..)	6	HR	$ 450.00	$ 2,700.00
Subtotal				**$ 139,050.00**

Item	Quantity	Unit	Cost	Price
WELL SERVICE COSTS				
4T Well Service Equipment; Mob/Demob	1	LS	$ 800.00	$ 800.00
Well Development Services (All Time On-Site)	170	HR	$ 200.00	$ 34,000.00
All Other Services (All Time On-Site)	85	HR	$ 200.00	$ 17,000.00
4T Rig Standby ('Client' Directed Work Stoppage..)	0	HR	$ 200.00	$ -
Subtotal				**$ 51,800.00**

Item	Quantity	Unit	Cost	Price
IDW CONTAINMENT AND SITE SECURITY COSTS				
Forklift & Tilt-Hopper; Transportation (R/T)	Included	EA	Included	Included
Forklift & Tilt-Hopper; Rental (Handle Drill Cuttings..)	Included	DY	Included	Included
55 Gallon 17H Drum	0	EA	$ 60.00	$ -
Visqueen Plastic Roll	26	EA	$ 160.00	$ 4,160.00
20 Yard Roll-off Bin; Transportation (R/T)	0	EA	Cost + 20%	$ -
20 Yard Roll-off Bin; Plastic Liner	0	EA	Cost + 20%	$ -
20 Yard Roll-off Bin; Daily Rental	0	DY	Cost + 20%	$ -
20 Yard Roll-off Bin; Profiling Fee	0	EA	Cost + 20%	$ -
20 Yard Roll-off Bin; Disposal Fee	0	EA	Cost + 20%	$ -
6,500 Gallon Baker Tank; Transportation (R/T)	0	EA	Cost + 20%	$ -
6,500 Gallon Baker Tank; Daily Rental	0	DY	Cost + 20%	$ -
5,000 Gallon Vacuum Truck Service (Gate to Gate)	0	HR	Cost + 20%	$ -
Well Site Protection; Free Standing Chain Link Fencing	0	EA	Cost + 20%	$ -
Well Site Protection; Security Guard (M-F; 5:00pm-7:00am)	0	DY	Cost + 20%	$ -
Well Site Protection; Security Guard (S-S; 24-Hours)	0	DY	Cost + 20%	$ -
Subtotal				**$ 4,160.00**

Estimated Project Total: $ 1,538,160.00

'YJD' Proposal Assumptions & Conditions:

1.) 'Client' to provide all Local, State, Federal project specific permits.
2.) All drilling locations are to be clear of any and all overhead & subsurface utilities.
3.) All drilling locations are accessible by way of 2-wheel drive truck mounted drilling & related equipment.
4.) All drill cuttings & fluids generated will be contained in 'Client' subcontracted storage vessels.
5.) All drill cuttings & fluids will be placed for storage within 100' of the working area. Containment beyond a distance of 100' will require the use of a forklift and/or loader.
6.) Profiling and disposal of all drill cuttings & fluids generated will be the responsibility of the 'Client'.
7.) An equipped 'Client' arranged/approved on-site water supply source will be made available during all drilling and related phases of the project.
8.) During the drilling operation, if there is no return of the circulated drilling medium for a period of at least two (2) continuous hours, the 'Client' representative will be notified. 'YJD' will be compensated for the period of drilling under "Lost Circulation" condition at the rate of $750.00/hour. Also 'YJD' will be compensated for all drilling fluid materials and additives required during the period of lost circulation. The condition of this section shall apply from the beginning of the time of notification until such time as circulation is regained with full or partial returns of the drilling medium to the land surface. After an initial lost circulation be lost again, the conditions of the paragraph will go into effect immediately and continue until such time as circulation is regained with full returns of the drilling medium at the land surface.
9.) During the drilling operation, if a "Hard or Unstable Formation" is encountered that results in a penetration rate of 20 feet per hour or less for a continuous period of two (2) hours, 'YJD' will be compensated for the drilling conditions at the rate of $750.00/hour. Also there will reasonable compensation to 'YJD' for all drilling bits and other materials used during the period of hard/unstable drilling conditions. The conditions shall apply from the beginning of the time of low penetration (less than 20 feet per hour) and shall continue only until such time as drilling is resumed at a rate of 20 feet per hour or greater.
10.) In the event that down-hole tooling (augers, drill pipe, drill collars, stabilizers, adaptor subs, down-hole hammers, drill bits..) is lost in the process of drilling in adverse ground conditions; 'Client' will reimburse 'YJD' for the replacement of the tooling at current replacement cost.

11.) In the event that sampling equipment (split-spoon, simulprobe, hydro punch..) is lost or damaged in the process of sampling in adverse ground conditions; 'Client' will reimburse 'YJD' for the replacement of the equipment at current replacement cost.
12.) Schedule/Pricing is based on a single rig operation; utilizing one (1) crew, working +/- 10/hour shifts, working a 10/on (Days) 4/off (Days) work schedule (Including Mob/Demob/Travel Time).
13.) Project is not subject to surcharges for Union/Davis Bacon/Prevailing labor rates.
14.) Drill rig standby due to unreadiness of the drilling locations or 'Client' delays will be billed at the provided hourly rate.
15.) If the project encounters difficulties beyond our control or if the scope of work is altered, 'YJD' reserves the right to renegotiate the price.
16.) Materials; due to the market price fluctuations of steel and petroleum based products; 'YJD' cannot guarantee the price of the materials required to complete the project beyond a period of 10-working days from the date in which the pricing is provided. In the event that a material price increase occurs; 'YJD' reserves the right to pass on the difference in the form of a revised proposal or by using the change order process.
17.) EIA Fuel Use Market Adjustment; due to the current price fluctuations of petroleum products 'YJD' has based the provided pricing on the most recent available weekly retail gasoline and diesel prices as reported by the Energy Information Administration ('EIA' - Official Energy Statistics from the US Government). 'YJD' has used the reported area average of ($4.17-Gallon) to calculate it's bid; in the event that the cost of fuel increases prior to the start and/or during the course of the project 'YJD' will invoice for the additional costs on a per-day basis. The per-day charge will be based on the difference of the fuel cost per-gallon at the time of bid; plus 20% mark-up verses the actual cost per-gallon during the time period in which the project is completed.
*NOTE: The multiplier to calculate the fuel use market adjustment on a per-day basis is based on the equipment package utilized; for this bid the daily multiplier is based on a fixed amount of 250-gallons.
18.) This proposal is valid for (60) days from the above date.

All services rendered will be billed promptly upon completion of work. Terms are net **thirty (30) days** unless otherwise agreed in writing in advance. A delinquency charge of 1.5% per month will apply to all past due invoices, unless a lower rate is required by law. Client agrees to pay all court costs and attorneys fees, should court proceedings be initiated or attorneys be retained to collect past due amounts.

We at Yellow Jacket Drilling Services thank you for the opportunity to provide this proposal. If you have any questions, or if we can be of any further assistance please do not hesitate to contact us at (602) 453-3252. We look forward to hearing from you soon.

Sincerely,
Yellow Jacket Drilling Services, LLC

John Truax

John Truax

Acceptance of all outlined pricing, terms and conditions:

Company Name:_________________________________

Authorized Representative (Name & Title):____

Signature:_________________________________

D3 – Alternative 3
ARD + Hydraulic Barrier

TABLE D3
Feasibility Screening Results
Phoenix-Goodyear Airport-North Superfund Site
Goodyear, Arizona

ESTIMATE OF PROBABLE COST

ARD + Hydraulic Barrier (Alternative 3)

NO.	ITEM	ESTIMATED QTY RANGE	UNIT (EA, LF, LS)	UNIT PRICE RANGE	ESTIMATED COST RANGE	COST SOURCE
1.00	**Permits, Design, and Work Plan**					
1.01	Health & Safety Plan	1 - 1	LS	$10,000 - $10,000	$10,000 - $10,000	Estimate from other sites
1.02	Underground Injection Control Permit	1 - 1	LS	$10,000 - $15,000	$10,000 - $15,000	Estimate from other sites
1.03	Bench-scale testing for bio	1 - 1	LS	$20,000 - $30,000	$20,000 - $30,000	Estimate from other sites
1.04	Permits, design, office support	1 - 1	LS	$80,062 - $80,062	$80,062 - $80,062	Estimate from other sites
1.05	Work Plan and Report	1 - 1	LS	$69,233 - $69,233	$69,233 - $69,233	Estimate from other sites
		Permits, Design, and Work Plan Subtotal:			***$189,300 - $204,300***	
2.00	**Full Scale Mobilization/Demobilization**					
2.01	Injection Contractor	352 - 352	LIFT	$2,000 - $2,000	$704,000 - $704,000	Quote in D-1
2.02	Drilling Contractor	1 - 1	LS	$1,500 - $3,000	$1,500 - $3,000	Quote in D-1
2.03	Fencing	5 - 5	LS	$2,300 - $2,300	$11,500 - $11,500	Quote in D-1
2.04	Aboveground piping installation from MTS	0 - 0	FT	$7 - $10	$0 - $0	NA
2.05	Secondary containment	25 - 30	MO	$500 - $1,000	$12,500 - $30,000	Quote in D-1
2.06	Tank rental and misc equipment	5 - 10	MO	$1,500 - $2,000	$7,500 - $20,000	Quote in D-1
		Full Scale Mobilization/Demobilization Subtotal:			***$737,000 - $768,500***	
3.00	**Injection and Monitoring Well Installation**					
3.01	Survey	1 - 2	DAY	$1,000 - $1,500	$1,000 - $3,000	Estimate from other sites
3.02	Driller installation, development of monitoring wells	12 - 12	WELL	$16,050 - $16,050	$192,600 - $192,600	Quote in D-1
3.03	Driller installation, development of permanent injection wells	64 - 64	WELL	$15,250 - $15,250	$976,000 - $976,000	Quote in D-1
3.04	YR 1 distribution coring	1 - 1	LS	$72,166 - $72,166	$72,166 - $72,166	Quote in D-1
3.05	Solid waste disposal	64 - 73	BIN	$500 - $750	$32,000 - $54,750	Quote in D-1
3.06	Connection to MTS for provision of treated water to source area	1 - 1	LS	$75,000 - $125,000	$75,000 - $125,000	Estimate from other sites
3.07	Analytical lab (24-hour TAT)	64 - 64	SAMPLE	$120 - $120	$7,680 - $7,680	Quote in D-1
3.08	Analytical lab (standard TAT)	0 - 0	SUITE	$621 $621	$0 $0	Quote in D-1
3.09	Oversight	1 - 1	LS	$84,418 - $84,418	$84,418 - $84,418	Estimate from other sites
3.10	Baseline sampling	76 - 76	WELL	$600 - $800	$45,600 - $60,800	Quote in D-1
		Injection and Monitoring Well Installation Subtotal:			***$1,486,500 - $1,576,400***	
4.00	**Year 1 Site Set-up and Injection Activities**					
4.01	Survey	1 - 2	DAY	$1,000 - $1,500	$1,000 - $3,000	Estimate from other sites
4.02	Site set-up (secondary containment, decon pad, H&S Equipment)	1 - 2	LS	$28,800 - $35,000	$28,800 - $70,000	Estimate from other sites
4.03	Fork-lift	1 - 1	LS	$2,875 - $2,875	$2,875 - $2,875	Quote in D-1
4.04	Waste management	5 - 10	LS	$500 - $1,000	$2,500 - $10,000	Quote in D-1
4.05	Injection oversight	1 - 1	LS	$219,632 - $219,632	$219,632 - $219,632	Estimate from other sites
4.06	Amendments (bioaugmentation culture)	2,880 - 2,880	LITERS	$200 - $200	$576,000 - $576,000	Quote in D-3
4.07	Amendments (oil)	1 - 1	LS	$147,262 - $147,262	$147,262 - $147,262	Quote in D-3

TABLE D3
Feasibility Screening Results
Phoenix-Goodyear Airport-North Superfund Site
Goodyear, Arizona

ESTIMATE OF PROBABLE COST

ARD + Hydraulic Barrier (Alternative 3)

NO.	ITEM	ESTIMATED QTY RANGE	UNIT (EA, LF, LS)	UNIT PRICE RANGE	ESTIMATED COST RANGE	COST SOURCE
4.08	Injections	144 - 144	PER LIFT	$3,399 - $3,399	$489,456 - $489,456	Estimate from other sites
4.09	Analytical suite (standard TAT)	42 - 42	SUITE	$621 - $621	$26,082 - $26,082	Quote in D-1
4.10	Data validation	1 - 1	LS	$5,000 $5,000	$5,000 $5,000	Estimate from other sites
4.11	Reporting and meetings	1 - 1	LS	$62,168 - $62,168	$62,168 - $62,168	Estimate from other sites
		Year 1 Site Set-up and Injection Activities Subtotal:			***$1,560,800 - $1,611,500***	
5.00	**Year 2 Site Set-up and Injection Activities**					
5.01	Survey	1 - 2	DAY	$1,000 - $1,500	$1,000 - $3,000	Estimate from other sites
5.02	Site det-up (secondary containment, decon pad, H&S Equipment)	1 - 2	LS	$28,800 - $35,000	$28,800 - $70,000	Estimate from other sites
5.03	Fork-lift	1 - 1	LS	$2,875 - $2,875	$2,875 - $2,875	Quote in D-1
5.04	Waste management	5 - 10	LS	$500 - $1,000	$2,500 - $10,000	Quote in D-1
5.05	Injection oversight	1 - 1	LS	$219,632 - $219,632	$219,632 - $219,632	Estimate from other sites
5.06	Amendments (bioaugmentation culture)	1,920 - 1,920	LITERS	$200 - $200	$384,000 - $384,000	Quote in D-3
5.07	Amendments (oil)	1 - 1	LS	$98,174 - $98,174	$98,174 - $98,174	Quote in D-3
5.08	Injections	96 - 96	PER LIFT	$3,399 - $3,399	$326,304 - $326,304	Estimate from other sites
5.09	Analytical suite (standard TAT)	42 - 42	SUITE	$621 - $621	$26,082 - $26,082	Quote in D-1
5.10	Data validation	1 1	LS	$5,000 $5,000	$5,000 $5,000	Estimate from other sites
5.11	Reporting and meetings	1 - 1	LS	$62,168 - $62,168	$62,168 - $62,168	Estimate from other sites
		Year 2 Site Set-up and Injection Activities Subtotal:			***$1,156,500 - $1,207,200***	
6.00	**Year 3 Site Set-up and Injection Activities**					
6.01	Survey	1 - 2	DAY	$1,000 - $1,500	$1,000 - $3,000	Estimate from other sites
6.02	Site set-up (secondary containment, decon pad, H&S Equipment)	1 - 2	LS	$28,800 - $35,000	$28,800 - $70,000	Estimate from other sites
6.03	Fork-lift	1 - 1	LS	$2,875 - $2,875	$2,875 - $2,875	Quote in D-1
6.04	Waste management	5 - 10	LS	$500 - $1,000	$2,500 - $10,000	Quote in D-1
6.05	Injection oversight	1 - 1	LS	$219,632 - $219,632	$219,632 - $219,632	Estimate from other sites
6.06	Amendments (bioaugmentation culture)	960 - 960	LITERS	$200 - $200	$192,000 - $192,000	Quote in D-3
6.07	Amendments (oil)	1 - 1	LS	$49,087 - $49,087	$49,087 - $49,087	Quote in D-3
6.08	Injections	48 - 48	PER LIFT	$3,399 - $3,399	$163,152 - $163,152	Estimate from other sites
6.09	Analytical suite (standard TAT)	42 - 42	SUITE	$621 - $621	$26,082 - $26,082	Quote in D-1
6.10	Data validation	1 - 1	LS	$5,000 $5,000	$5,000 $5,000	Estimate from other sites
6.11	Reporting and meetings	1 - 1	LS	$62,168 - $62,168	$62,168 - $62,168	Estimate from other sites
		Year 3 Site Set-up and Injection Activities Subtotal:			***$752,300 - $803,000***	

TABLE D3
Feasibility Screening Results
Phoenix-Goodyear Airport-North Superfund Site
Goodyear, Arizona

ESTIMATE OF PROBABLE COST

ARD + Hydraulic Barrier (Alternative 3)

NO.	ITEM	ESTIMATED QTY RANGE	UNIT (EA, LF, LS)	UNIT PRICE RANGE	ESTIMATED COST RANGE	COST SOURCE
7.00	**Year 4 Site Set-up and Injection Activities**					
7.01	Survey	1 - 2	DAY	$1,000 - $1,500	$1,000 - $3,000	Estimate from other sites
7.02	Site set-up (secondary containment, decon pad, H&S Equipment)	1 - 2	LS	$28,800 - $35,000	$28,800 - $70,000	Estimate from other sites
7.03	Fork-lift	1 - 1	LS	$2,875 - $2,875	$2,875 - $2,875	Quote in D-1
7.04	Waste management	5 - 10	LS	$500 - $1,000	$2,500 - $10,000	Quote in D-1
7.05	Injection oversight	1 - 1	LS	$219,632 - $219,632	$219,632 - $219,632	Estimate from other sites
7.06	Amendments (bioaugmentation culture)	960 - 960	LITERS	$200 - $200	$192,000 - $192,000	Quote in D-3
7.07	Amendments (oil)	1 - 1	LS	$49,087 - $49,087	$49,087 - $49,087	Quote in D-3
7.08	Injections	48 - 48	PER LIFT	$3,399 - $3,399	$163,152 - $163,152	Estimate from other sites
7.09	Analytical suite (standard TAT)	42 - 42	SUITE	$621 - $621	$26,082 - $26,082	Quote in D-1
7.10	Data validation	1 - 1	LS	$5,000 $5,000	$5,000 $5,000	Estimate from other sites
7.11	Reporting and meetings	1 - 1	LS	$62,168 - $62,168	$62,168 - $62,168	Estimate from other sites
		Year 4 Site Set-up and Injection Activities Subtotal:			***$752,300 - $803,000***	
8.00	**Year 5 Site Set-up and Injection Activities**					
8.01	Survey	1 - 2	DAY	$1,000 - $1,500	$1,000 - $3,000	Estimate from other sites
8.02	Site set-up (secondary containment, decon pad, H&S Equipment)	1 - 2	LS	$28,800 - $35,000	$28,800 - $70,000	Estimate from other sites
8.03	Fork-lift	1 - 1	LS	$2,875 - $2,875	$2,875 - $2,875	Quote in D-1
8.04	Injection oversight	1 - 1	LS	$219,632 - $219,632	$219,632 - $219,632	Estimate from other sites
8.05	Amendments (bioaugmentation culture)	720 - 720	LITERS	$200 - $200	$144,000 - $144,000	Quote in D-3
8.06	Amendments (oil)	1 - 1	LS	$36,815 - $36,815	$36,815 - $36,815	Quote in D-3
8.07	Injections	36 - 36	PER LIFT	$3,399 - $3,399	$122,364 - $122,364	Estimate from other sites
8.08	Analytical suite (standard TAT)	42 - 42	SUITE	$621 - $621	$26,082 - $26,082	Quote in D-1
8.09	Data validation	1 - 1	LS	$5,000 $5,000	$5,000 $5,000	Estimate from other sites
8.10	Reporting and meetings	1 - 1	LS	$62,168 - $62,168	$62,168 - $62,168	Estimate from other sites
		Year 5 Site Set-up and Injection Activities Subtotal:			***$648,700 - $691,900***	
	CONSTRUCTION AND MATERIALS COST SUBTOTAL (TASKS 1-8):				**$7,283,400 - $7,665,800**	
9.00	**Years 6-8 Performance Monitoring**					
9.01	Long-term monitoring and analytical costs	1 - 1	YR	$145,431 - $145,431	$145,431 - $145,431	Estimate from other sites
9.02	Reporting	1 - 1	YR	$132,268 - $132,268	$132,268 - $132,268	Estimate from other sites
		Years 6-8 Performance Monitoring Subtotal:			***$277,700 - $277,700***	
				NPV for O&M:	***$820,800 - $820,800***	
	O&M COST SUBTOTAL (TASK 9):				**$820,800 - $820,800**	

TABLE D3
Feasibility Screening Results
Phoenix-Goodyear Airport-North Superfund Site
Goodyear, Arizona

ESTIMATE OF PROBABLE COST

ARD + Hydraulic Barrier (Alternative 3)

NO.	ITEM	ESTIMATED QTY RANGE	UNIT (EA, LF, LS)	UNIT PRICE RANGE	ESTIMATED COST RANGE	COST SOURCE
10.00	**Closure Costs**					
10.01	Abandon injection wells	64 - 64	WELL	$1,850 - $2,565	$118,400 - $164,160	Quote in D-1
10.02	Abandon groundwater wells	12 - 12	WELL	$1,760 - $2,475	$21,120 - $29,700	Quote in D-1
10.03	Solid waste disposal	38 - 76	BIN	$500 - $750	$19,000 - $57,000	Quote in D-1
10.04	Site restoration	1 - 1	LS	$25,000 - $50,000	$25,000 - $50,000	Estimate from other sites
10.05	Oversight	1 - 1	LS	$120,000 - $120,000	$120,000 - $120,000	Estimate from other sites
10.06	Reporting and meetings	1 - 1	LS	$60,000 - $100,000	$60,000 - $100,000	Estimate from other sites
	CLOSURE COST SUBTOTAL (TASK 10):				**$363,520 $520,860**	
		TOTAL COST (BARE):			**$8,467,720 - $9,007,460**	
		AVERAGE COST (BARE):			**$8,737,600**	
	TOTAL COST WITH -30% TO +50% CONTINGENCY:				**$6,116,300 - $13,106,400**	

www.siremlab.com
130 Research Lane, Suite 2
Guelph, Ontario N1G 5G3
Phone: (519) 822-2265
Fax: (519) 822-3151

7 November 2011 SiREM Ref: Si-1460-110711

Chris Tsiatsios
Haley & Aldrich
3187 Red Hill Ave #155
Costa Mesa, CA 92626

via email: CTsiatsios@haleyaldrich.com

Reference: Quotation for KB-1® Bioaugmentation, Phoenix, Arizona

Dear Chris:

SiREM has prepared this proposal to provide KB-1® for bioaugmentation at an unidentified site in Phoenix, Arizona (the Site). SiREM has prepared this quotation based on information provided in our telephone conversation of 4 November 2011 and quote request form received 2 November 2011.

Understanding of Site Conditions & Project Scope

The information provided regarding chemical conditions at the Site is summarized in Table 1, the geology and hydrogeology are summarized in Table 2, and the Site dimensions, operational features and field application parameters are summarized in Table 3. There are 54 injection points proposed for the application of KB-1®. The injections will take place over a period of 5 to 6 years with KB-1® being applied to approximately 9 injection points per year.

Monitoring and Site Management Requirements for Validation of KB-1® Guarantee

To ensure the Site is compatible with bioaugmentation using KB-1®, to assess progress after bioaugmentation and to validate the KB-1® guarantee, SiREM requires that the parameters summarized in Table 4 be determined as indicated. The KB-1® guarantee requires that pH, dissolved oxygen (DO), oxidation reduction potential (ORP), sulfate, 1,1,1-trichloroethane (1,1,1-TCA), chloroform and chlorinated ethene concentrations be within the ranges specified. Furthermore, most sites require the addition of an electron donor prior to bioaugmentation to establish the required reducing conditions for bioaugmentation. Thereafter, the Site must be maintained as specified for the duration of the remediation.

After bioaugmentation, the post-bioaugmentation parameters specified in Table 4 should be assessed within a period approximating the response time (e.g., 3 to 4 months after bioaugmentation).

Scope of Supply

SiREM will supply:

1. One thousand eighty (1,080) liters (L) of KB-1® culture.
2. Shipment of culture vessels and all equipment required for the injection of KB-1®, to/from the Site.
3. Two (2) Gene-Trac® VC molecular genetic analysis to confirm the successful introduction and distribution of *Dehalococcoides* organisms in the KB-1® culture.

SiREM recommends that Gene-Trac® VC molecular genetic analyses be conducted to confirm the successful introduction and distribution at the Site of *Dehalococcoides* organisms in the KB-1® culture.

Due to the concentrated nature of our product, a smaller application volume of KB-1® may be specified than for competing products. As part of SiREM's KB-1® quality control program, *Dehalococcoides* quantification is conducted on each batch of KB-1® prior to shipment to the field. SiREM targets a *Dehalococcoides* concentration of 1 x 10^{11} gene copies per L of KB-1®; however, this standard is routinely exceeded.

Please note, SiREM requires a minimum notice of 4 weeks notice to ensure supply of the quoted volume of culture. Shipping of the culture will occur approximately one week in advance of when it is required at the Site to allow sufficient time for both shipping and customs clearance.

<u>Optional Field Bioaugmentation Technician Support</u>

In addition to above and at your request, SiREM can provide a cost estimate for an OSHA certified bioaugmentation field technician to perform the KB-1® injections or to train your staff at the Site.

Anticipated Results

We anticipate that the proposed bioaugmentation will result in reductive dechlorination of chlorinated ethenes in approximately four months ("the response time") as evidenced by significant trends in production of ethene and/or increasing *Dehalococcoides* concentrations. Should the commencement of complete dechlorination, or increases in *Dehalococcoides* populations, not be achieved within the specified response time, and if all conditions outlined under Table 4, "Monitoring and Site Management Requirements for Validation of KB-1® Guarantee", are fulfilled, the guarantee (attached) will be applicable.

Cost Quotation

The cost for KB-1® bioaugmentation (not including shipping) based on our current understanding of the Site conditions is $162,000 (fixed price plus applicable local and state taxes, refer to Table 5). Shipping costs are estimated to be $10,860 and will be finalized upon acceptance of this proposal and provision of a final delivery schedule and address. Quantitative Gene-Trac® VC analyses beyond the two included with the bioaugmentation can be purchased at a unit cost of $285 per test.

Terms and Conditions

The contract terms and conditions applicable to microbial product sales are unique. To minimize the administrative efforts between our firms and to facilitate this business transaction, SiREM recommends, that this proposal be governed by the attached terms and conditions (Attachment B). Your signature below will confirm your acceptance of SiREM's terms and conditions. If you desire to use your own contract form, please forward it to my attention. As soon as we have reached agreement on the terms, SiREM will proceed with its services.

Please note that SiREM is a division of Geosyntec Consultants, Inc, a corporation organized under the laws of the State of Florida.

If SiREM's proposal is acceptable, please indicate agreement by having an authorized representative sign in the space provided below and return a complete copy of this proposal and attachments to my attention. Should you have any questions or need additional information regarding this quotation or KB-1® bioaugmentation please contact me at 1-866-251-1747 x 228.

Sincerely,

Jeff Roberts

Jeff Roberts, M.Sc.
Laboratory Manager

Attachment A: KB-1® Guarantee and Use Limitations
Attachment B: Terms and Conditions for Microbial Product Sales

Agreed and Accepted By:

SiREM Proposal: Si-1460-110711	Proposal Amount: $172,860 plus local and State taxes	
Authorized Signature		Date:
Printed Name		
Fax & Email Address		
Purchase Order	PO #	☐ No PO will be issued
Prime Contract	☐ Applies, Copy Attached	☐ No Prime Contract Applies

Table 1: Site Conditions Pre-bioaugmentation

Chlorinated ethenes (µg/L)	Maximum	Average
Tetrachloroethene	25	5
Trichloroethene	41,000	1000
cis-1,2-Dichloroethene	25	6
trans-Dichloroethene	25	3.5
1,1- Dichloroethene	25	5
Vinyl chloride	25	5
Chlorinated ethanes		
1,1,1-Trichloroethane	25	5
1,1,2- Trichloroethane	--	--
1,1- Dichloroethane	--	--
1,2- Dichloroethane	--	--
Chlorinated methanes		
Carbon tetrachloride	--	--
Chloroform	25	5
Methylene Chloride	--	--
Biogenic gases (mg/L)		--
Methane	--	--
Ethane	--	--
Ethene	--	--
Inorganic parameters (mg/L)		--
Nitrate	20	13
Sulfate	600-800	--
Total iron	--	--
Dissolved Manganese	--	--
Chloride	--	--
Field parameters		
ORP (mV)	-184 to -74	-30
Dissolved Oxygen (DO) mg/L	5.5	3.7
Temperature (°C)	--	--
pH	7-8.5	7.6
Specific Conductance (µS/cm)	--	--

Note:
-- - data for this parameter not provided
ND – not detected
NA – not analyzed

Table 2: Geology/ Hydrogeology

Matrix	ML/CL and SM/SL
Groundwater Velocity (feet/day)	1.0
Bulk Hydraulic Conductivity (cm/s)	--
Hydraulic Gradient	--
Heterogeneity	--
Saturated thickness (impacted zone) (feet)	60
Porosity	0.30

Note: -- = data for this parameter were not provided

Table 3: Site Dimensions and Operational Features

Treatment zone	700 X 220
Groundwater volume (L)	78,503,040
System operation	Passive
Proposed electron donor	EVO and nZVI
Proposed # of injection points	54 (~9 per year for 5 to 6 years)
Volume KB-1® per injection point (Liters)	20

Table 4: Monitoring Requirements for Validation of the KB-1® Guarantee

Parameter	Target	Pre-bioaugmentation	Post-bioaugmentation
pH	6.0 - 8.5	✓	✓
Chlorinated ethenes (PCE, TCE, cDCE, vinyl chloride)	> 100 µg/L	✓	✓
1,1,1-Trichloroethane	< 200 µg/L	✓	✓
Chloroform	< 50 µg/L	✓	✓
Dissolved hydrocarbon gases (methane, ethene ethane)	NA	✓	✓
Dissolved oxygen (DO)	< 0.2 mg/L	✓	✓
Oxidation-reduction potential (ORP)	< - 75 mV	✓	✓
Sulfate	< 1,000 mg/L	✓	x
Dehalococcoides organisms	NA	x	✓

Notes: ✓ = Analysis required at time point indicated for validation of guarantee
x = Analysis recommended at time point indicated but not required for validation of guarantee
NA = Not applicable (no target range for this parameter)

Table 5: Fixed-Fee Cost Quote for KB-1® Bioaugmentation

Item	Number of Units	Unit Cost	Total Cost
KB-1® Culture, Including Preparation	1,080 Liters	$150	$162,000*
Estimated Outbound and Return Shipping and Brokerage Charges	6 Shipping Events	$1,810	$10,860
Gene-Trac® VC *Dehalococcoides* Analyses	2 Tests	$285	$0 Included free of charge
Total			**$172,860**

*plus applicable state and local taxes

Abbreviations:
ND = Not detected, µg/L = micrograms per liter, mg/L = milligrams per liter, mV = millivolts, ºC = degrees Celsius, NA = not applicable

Guarantee: KB-1® Guarantee applies if validation requirements are fulfilled.

Disclaimer: This quotation has been prepared based on the information provided to SiREM regarding Site conditions and project approach. It is assumed by SiREM that the information provided by the client is complete and correct. SiREM reserves the right to refine this quotation as new information is provided regarding Site conditions or project approach. This quotation is valid for one year.

SiREM
Site Recovery & Management

Attachment A: KB-1® Guarantee and Use Limitations

KB-1® Guarantee and Use Limitations

SiREM, a division of Geosyntec Consultants, Inc, is an authorized distributor of KB-1® Dechlorinator (KB-1®), a proprietary product. All product sales or applications of KB-1® are subject to the following terms and conditions which shall constitute the entire agreement between the parties with respect to the sale or application of KB-1® and supersede all prior or contemporaneous communications, representations, or agreements, whether oral or written, relating to the subject matter set forth herein.

CONDITIONS REQUIRED TO VALIDATE GUARANTEE:

- KB-1® is injected only by SiREM staff or their approved designate;
- initial chlorinated ethene concentrations at the site are sufficient to sustain the growth of *Dehalococcoides* (DHC) organisms (i.e., in excess of 100 micrograms per liter [µg/L]);
- inhibitory compounds/conditions (i.e., chloroform concentrations in excess of 50 µg/L, 1,1,1-TCA in excess of 200 µg/L) are absent;
- geochemical conditions must be consistent with reductive dechlorination (i.e., redox levels [ORP] below -75 milliVolts [mV], dissolved oxygen levels less than 0.2 milligrams per Liter [mg/L], depletion of sulfate and nitrate, average groundwater temperature above 10°C, and pH between 6 and 8.5);
- suitable electron donor is provided at appropriate concentration consistently; and
- the site is not physically, chemically or geochemically disrupted after bioaugmentation.

After bioaugmentation, DHC organisms attributable to KB-1® will colonize the site as determined by increasing DHC concentrations and/or dispersing DHC populations (based on Quantitative Gene-Trac DHC and/or Gene-Trac-VC tests) and/or the appearance of, or increases in, the concentration of ethene (hereafter referred to as "impact[s]"). The impact(s) are guaranteed to occur within the response time provided in the anticipated results section of SiREM's proposal at either the injection point(s), or downgradient, provided the above site conditions are maintained throughout the bioaugmentation and acclimation (response time) period.

LIMITED PERFORMANCE GUARANTEE: In the event that bioaugmentation is unsuccessful, as deemed by the absence of impact(s) at the injection points, or downgradient, within the designated response time, SiREM will provide an additional quantity of KB-1® free of charge (including delivery and associated expenses) equal to the initial volume of KB-1® used at the location(s) for which bioaugmentation is deemed unsuccessful. Should additional bioaugmentation prove ineffective, SiREM will refund, in full, the cost of the KB-1® culture for the specific locations where bioaugmentation is deemed to be unsuccessful.

ADDITIONAL CONDITIONS: This limited guarantee is conditional upon receipt of payment in full for KB-1® purchases. SiREM reserves the right, at its sole discretion, to confirm the concentration of ethene/ethane, *Dehalococcoides* organisms and other relevant geochemical parameters by collection and submission of groundwater or soil samples to a mutually agreeable independent laboratory. **No other warranty, expressed or implied, including, but not limited to, any and all warranties of merchantability and/or fitness for a particular purpose is made or intended.**

RESTRICTIONS AND LIMITATIONS

KB-1® may only be used as set forth in the use specifications provided by SIREM, which specifications are hereby fully incorporated herein by reference.

KB-1® may only be used at the project site identified in SiREM's proposal.

KB-1® may not be sold, or resold or transferred any to any third party under any circumstances.

KB-1® may not be "reverse engineered" nor shall any activity be undertaken which would enable person or entity, to duplicate or imitate the KB-1® culture, or to grow the KB-1® culture.

There are no third party beneficiaries made or intended as to the sale of KB-1® culture.

Attachment B: Terms and Conditions for Microbial Product Sales

Product Sales Order. These Terms and Conditions (T&Cs) apply to all sales of microbial products ("Product") by SiREM. Such sales are initiated by a purchase order, quote or acceptance of a proposal ("Order").

Invoicing and Payment. SiREM shall invoice Client 25% of the total price upon Client's acceptance of the Order and the balance upon shipment. Payment is due within 30 days of Client's receipt of SiREM's invoice. Client shall pay an additional charge of one percent (1%) of the amount of the invoice per month or the maximum percentage allowed by law, whichever is the lesser, for any payment received by SiREM beyond the payment terms set forth herein.

Shipping. Product will be shipped to the project site, or other location designated by Client as set forth in the Order. Shipping of Product will be by common carrier. The cost of shipping will be included in SiREM's invoice.

Client's Prime Contract. In the event that the Order is pursuant to Client's federal or state funded prime contract, SiREM will comply with the mandatory flow down clauses of such prime contract. For other than federal or state prime contracts, Client agrees to provide a copy of applicable flow down requirements to SiREM concurrent with Client's acceptance of SiREM's order/quote or proposal. SiREM reserves the right to consider such flow down T&Cs prior to the shipment of Product.

Limited Guaranty. SiREM provides a Limited Guarantee in connection with the sale of Product as set forth in the attached Supplemental T&Cs. Provided that the conditions set forth therein are met, SiREM, under the circumstances described therein, will provide an additional quantity of Product free of charge or, if that fails to achieve the described results, refund the cost of the Product. THIS LIMITED GUARANTEE CONSTITUTES CLIENT'S EXCLUSIVE REMEDY WITH RESPECT TO THE USE OF THE PRODUCT AND ALL OTHER WARRANTIES OF ANY KIND, WHETHER EXPRESS, IMPLIED, OR STATUTORY, INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, ARE HEREBY DISCLAIMED.

Intellectual Property Rights/Obligations. The Product is subject to Intellectual Property Rights which are owned by others. SiREM is an authorized seller of the Product provided that buyers agree to limitations on usage. Therefore, Client agrees to use the Product only as set forth in the Order, and only at the project site described in the Order, and at no other site and for no other project or purpose, and to not sell, resell or transfer any of the Product to any third party under any circumstances. In addition, Client agrees that it will not "reverse engineer" or undertake any activity which would enable Client, or any other person or entity, to duplicate, imitate, grow or culture the Product.

Consequential Damages. In no event will SiREM be liable to Client for any incidental or consequential damages arising in connection with the use of the Product.

Confidentiality. SiREM will maintain as confidential any documents or information provided by Client and will not release, distribute or publish the same to any third party without prior permission from Client, unless compelled by law or order of a court or regulatory body of competent jurisdiction. In such event, SiREM will provide advance written notice to Client prior to release.

Delays and Force Majeure. Neither party will hold the other responsible for damages or delays in performance caused by force majeure, acts of God, or other events beyond the reasonable control of the delayed party.

Termination. Client may terminate all or any portion of an Order prior to the shipment of Product by written notice to SiREM.

Assignments/Third Parties. Neither party to this Agreement will assign its duties and obligations hereunder without the prior written consent of the other party. There are no intended third-party beneficiaries of the Order.

Validity. These T&Cs will be enforced to the fullest extent permitted by law. If any provision is found to be invalid or unenforceable, the provision will be construed and applied in a way that comes as close as possible to expressing the intention of the parties and that saves the validity and enforceability of the provision.

Notices: Any information or notices required or permitted under the Order will be deemed to have been sufficiently given if in writing and delivered either personally or by mail to the representatives of the parties as set forth in the order/quote or proposal or as otherwise designated by the parties. Notice given by mail will also be transmitted by facsimile or email at the time of mailing.

Integrated Writing. The Order and these T&Cs, together with any Supplemental T&Cs attached hereto, constitute a final and complete repository of the agreements between Client and SiREM and supersede all prior or contemporaneous communications, representations, or agreements, whether oral or written and shall only be modified through a mutually acceptable written addendum hereto. It is expressly agreed by the parties that if Client issues a Purchase Order or similar document, it shall be solely for financial authorization purposes and any Terms and conditions contained therein shall not modify these T&Cs.

TC-Product SalesV11-09.doc

Remediation and Natural Attenuation Services, Inc.

6712 West River Road
Brooklyn Center, MN 55430

(763) 585-6191
fax: (763) 585-6195

November 23, 2011

Paula Chang
Remediation Program Manager
Haley & Aldrich, Inc.
2328 N. Malachite Circle
Mesa, AZ 85207-2425

Re: Conceptual Design and Price Quote for Newman Zone Emulsion – Phoenix – Goodyear Airport – North Superfund Site

Dear Ms. Chang:

The approximate stoichiometric hydrogen demand was determined using the aquifer volume defined by the area between the proposed biobarriers,the average depths defined by those barriers, and an assumed effective porosity of 0.07. A simple calculation based on a sulfate concentration of 800 mg/L and 5 mg/L of Trichloroethene (TCE) within this volume was calculated using the mass ratios provided in table C.5 of the AFCEE Document *Principles and Practices of Enhanced Anaerobic Bioremediation of Chlorinated Solvents* from August of 2004.

The competing electron acceptor sulfate dominated demand and the 800 mg/L is a reasonable estimate of existing sulfate concentrations. The TCE present in the source area likely exists as both dissolved and adsorbed phase material, but we assume there is no significant DNAPL mass. Although we have no estimate of the adsorbed phase the source area concentrations range from about 1 mg/L to 5 mg/L and our assumption of the entire pore volume containing 5 mg/L TCE should account for a reasonable amount of adsorbed phase TCE, but not DNAPL.

Using just the hydrogen demand of sulfate and TCE in one pore volume of this source area treatment zone we have determined that approximately 75.7 mg/L of hydrogen demand is present in the pore water and one pore volume has the equivalent stoichiometric hydrogen demand of 3,214 pounds. We have not accounted for any flux of sulfate and TCE from upgradient of the treatment area and we also have not accounted for any hydrogen demand from oxidized iron within the treatment are soils since we have no data to accurately account for either. To be safe and provide for enough electron donor to keep the barriers active for several years we will apply a safety factor of 10x so our goal is to provide an total hydrogen delivery of 32,140 pounds from the electron donor.

Assuming that we produce 0.359 pounds of hydrogen per pound of vegetable oil which assumes complete utilization of acetic acid we will need 32,140 pounds hydrogen/0.359=89,526 pounds of vegetable oil. Using a Newman Zone emulsion with 46% oil by weight we would need approximately 194,623 pounds of Newman Zone. To deliver this quantity of vegetable oil and meet the proposed 10x stoichiometric hydrogen demand target.

In the figure that was provided to RNAS there are a total of eight proposed emulsion barriers across the plume, all approximately 300 feet wide, but varying in vertical depth from as deep as 55 feet to as shallow as 15 feet. The amount of emulsion needed for the first two barriers placed in the first year is about 88,465 pounds so rounding to the nearest 2,100 pound tote we would need 42 totes or 88,200 pounds for the first two barriers in year one. The second year two more barriers would be placed using 53,079 pounds of emulsion, 25 totes would deliver 52,500 pounds of emulsion. In years three and four we need approximately 26,540 pounds of emulsion so 13 totes at and 27,300 pounds will be assume for each of those years.

At current emulsion prices we can provide between 100,000 pounds and 200,000 pounds of packaged emulsion in totes for $1.25/pound. Shipping for a full truckload of 20 totes is currently $3,400. Bulk emulsion could be provided at $1.15/pound in bulk tanker loads, but we have not yet found a carrier that will bid this for delivery costs. Haley and Aldrich would have to provide for a bulk tank that can receive approximately 6,000 gallons of capacity for each 48,000 pound tanker load. I would assume we will be able to eventually find a carrier than can deliver a 48,000 pound load in a tanker truck with an onboard pump and hoses for about $4,500.

Costs for each year in the cost summary are based on this years shipping and emulsion price. You may want to adjust for an assumed 3% to 5% price increase each year for both transport and materials. We only have full truckload rates, but I will estimate the less than truckload costs by assuming that LTL shipping is about 1.5x higher than a full truckload. The price assumes a 46% soybean oil, 4% sodium lactate formulation and could be applied to either the 190-6722 or 190-6730 Newman Zone formulations.

Cost Summary for Emulsion in Totes Only

Year One 42 Totes 88,200 Pounds

- 88,200 pounds of emulsion $1.25/pound $110,250
- Shipping two full truckloads $3,400/each $6,800
- Shipping two totes LTL $255/tote $510

Cost of shipping and materials not including tax $117,560

Year Two 25 Totes 52,500 Pounds

- 52,500 pounds of emulsion $1.25/pound $65,625
- Shipping one full truckload $3,400/each $3,400
- Shipping five totes LTL $255/tote $1,275

Cost of shipping and materials not including tax $70,300

Year Three 13 Totes 27,300 Pounds

- 27,300 pounds of emulsion $1.25/pound $34,125
- Shipping 13 totes LTL $255/tote $3,315

Cost of shipping and materials not including tax $37,440

Year Four 13 Totes 27,300 Pounds

- 27,300 pounds of emulsion $1.25/pound $34,125
- Shipping 13 totes LTL $255/tote $3,315

Cost of shipping and materials not including tax $37,440

Cost Summary for Emulsion in Bulk Tanker Loads Plus Totes

Year One 88,200 Pounds Bulk Emulsion Two Loads

- 88,200 pounds of emulsion $1.15/pound $101,430
- Shipping two full tanker loads $4,500/each $9000

Cost of shipping and materials not including tax $110,430

Year Two 48,000 pounds Bulk Emulsion and Two Totes

- 48,000 pounds of emulsion $1.15/pound $55,200
- Two totes 2,200 pounds $1.25/pound $5,250
- Shipping one tanker load $4,500/each $4,500
- Shipping two totes LTL $255/tote $510

Cost of shipping and materials not including tax $65,460

Year Three 13 totes 27,300 pounds

- 27,300 pounds of emulsion $1.25/pound $34,125
- Shipping 13 totes LTL $255/tote $3,315

Cost of shipping and materials not including tax $37,440

Year Four 13 totes 27,300 pounds

- 27,300 pounds of emulsion $1.25/pound $34,125
- Shipping 13 totes LTL $255/tote $3,315

Cost of shipping and materials not including tax $37,440

By using some bulk loads during the first two years there is an estimated cost savings of about $11,970, but to maximize savings for bulk delivery options adjusting the injection schedule to allow for delivery of full 48,000 pound tanker loads would be needed. The costs associated with Haley and Aldrich having to provide for bulk tank storage should be weighed against the convenience of totes.

We also discussed options for combining Newman Zone emulsion with nano-iron injections. Based on the previous pilot testing the iron should be able to consume about half of the sulfates hydrogen demand and significant amount of the TCE contaminant. In order to ensure good distribution in silt and clay soils I would like to make sure we have at least 1% vegetable oil by volume in the injection fluid so soil adsorption does not prevent migration after the jetting process has been completed.

In order to estimate the minimum amount of emulsion needed for a co-injection using 2% by volume Newman Zone and 1% oil by volume we looked at the proposed injection volume of 2,400 gallons per lift and the number of lifts that would be used during each year's injection event. In the first year the proposed injections would require a total of 87 lifts and 208,800 gallons of injection fluid, 4,176 gallons of Newman Zone or about 34,452 pounds (emulsion density is assumed to be 8.25 pounds per gallon). Rounding to the nearest tote we would ship 16 totes or 33,600 pounds. In the second year there are 94 lifts requiring 225,600 gallons of injection fluid, 4,512 gallons of Newman Zone or about 37,224 pounds. Rounding to the nearest tote we would delivery 18 totes and 37,800 pounds. In the third year there are 48 lifts requiring 115,200 gallons of injection fluid, 2,304 gallons of Newman Zone or about 19,008 pounds. We would ship nine totes with 18,900 pounds of emulsion net contents. The four year requires 45 lifts, 108,000 gallons of injection fluid, 2,160 gallons of Newman Zone or about 17,800 pounds. We would ship nine totes or 18,900 pounds.

Cost Summary for Co-Injection Option Emulsion in Totes Only

Year One 16 Totes 33,600 Pounds

- 33,600 pounds of emulsion $1.25/pound $42,000
- Shipping one full truckloads $3,400/each $3,400

Cost of shipping and materials not including tax $45,400

Year Two 18 Totes 37,800 Pounds

- 37,800 pounds of emulsion $1.25/pound $47,250
- Shipping one full truckload $3,400/each $3,400

Cost of shipping and materials not including tax $50,650

Year Three 9 Totes 18,900 Pounds

- 18,900 pounds of emulsion $1.25/pound $23,625
- Shipping 9 totes LTL $255/tote $2,295

Cost of shipping and materials not including tax $25,920

Year Four 9 Totes 18,900 Pounds

- 18,900 pounds of emulsion $1.25/pound $23,625
- Shipping 9 totes LTL $255/tote $2,295

Cost of shipping and materials not including tax $25,920

I don't think these quantities would justify looking at a bulk shipment option. If we could arrange the injection schedule for a three year time span with deliveries that were approximately the same as a 48,000 pound bulk load then a significant cost savings could be achieved with a bulk delivery option.

Feel free to call me with any questions.

Sincerely,

William A. Newman
President – Senior Scientist

D4 – Alternative 4
nZVI + ZVI + ARD + Hydraulic Barrier

TABLE D4a
Feasibility Screening Results
Phoenix-Goodyear Airport-North Superfund Site
Goodyear, Arizona

ESTIMATE OF PROBABLE COST

nZVI + ZVI + ARD + Hydraulic Barrier (Alternative 4)

NO.	ITEM	ESTIMATED QTY RANGE	UNIT (EA, LF, LS)	UNIT PRICE RANGE	ESTIMATED COST RANGE	COST SOURCE
1.00	**Permits, Design, and Work Plan**					
1.01	Health & Safety Plan	1 - 1	LS	$10,000 - $10,000	$10,000 - $10,000	Estimate from other sites
1.02	Underground Injection Control Permit	1 - 1	LS	$10,000 - $15,000	$10,000 - $15,000	Estimate from other sites
1.03	Bench-scale testing for bio	1 - 1	LS	$20,000 - $30,000	$20,000 - $30,000	Estimate from other sites
1.04	Permits, design, office support	1 - 1	LS	$80,062 - $80,062	$80,062 - $80,062	Estimate from other sites
1.05	Work Plan and Report	1 - 1	LS	$69,233 - $69,233	$69,233 - $69,233	Estimate from other sites
		Permits, Design, and Work Plan Subtotal:			***$189,300 - $204,300***	
2.00	**Full Scale Mobilization/Demobilization**					
2.01	Injection Contractor	160 - 160	LIFT	$2,000 - $2,000	$320,000 - $320,000	Quote in D-1
2.02	Drilling Contractor	1 - 1	LS	$1,500 - $3,000	$1,500 - $3,000	Quote in D-1
2.03	Fencing	5 - 5	LS	$2,300 - $2,300	$11,500 - $11,500	Quote in D-1
2.04	Aboveground piping installation from MTS	0 - 0	FT	$7 - $10	$0 - $0	NA
2.05	Secondary containment	25 - 30	MO	$500 - $1,000	$12,500 - $30,000	Quote in D-1
2.06	Tank rental and misc equipment	5 - 10	MO	$1,500 - $2,000	$7,500 - $20,000	Quote in D-1
		Full Scale Mobilization/Demobilization Subtotal:			***$353,000 - $384,500***	
3.00	**Injection and Monitoring Well Installation**					
3.01	Survey	1 - 2	DAY	$1,000 - $1,500	$1,000 - $3,000	Estimate from other sites
3.02	Driller installation, development of monitoring wells	12 - 12	WELL	$16,050 - $16,050	$192,600 - $192,600	Quote in D-1
3.03	Driller installation, development of Permanent Injection Wells	45 - 45	WELL	$15,250 - $15,250	$686,250 - $686,250	Quote in D-1
3.04	YR 1 distribution coring	1 - 1	LS	$72,166 - $72,166	$72,166 - $72,166	Quote in D-1
3.05	Solid waste disposal	54 - 65	BIN	$500 - $750	$27,000 - $48,750	Quote in D-1
3.06	Connection to MTS for provision of treated water to source area	1 - 1	LS	$75,000 - $125,000	$75,000 - $125,000	Estimate from other sites
3.07	Analytical lab (24-hour TAT)	45 - 54	SAMPLE	$120 - $120	$5,400 - $6,480	Quote in D-1
3.08	Analytical lab (standard TAT)	0 - 0	SUITE	$621 $621	$0 $0	Quote in D-1
3.09	Oversight	1 - 1	LS	$84,418 - $84,418	$84,418 - $84,418	Estimate from other sites
3.10	Baseline Sampling	59 - 59	WELL	$800 - $1,200	$47,200 - $70,800	Quote in D-1
		Injection and Monitoring Well Installation Subtotal:			***$1,191,000 - $1,289,500***	
4.00	**Year 1 Site Set-up and Injection Activities**					
4.01	Survey	1 - 2	DAY	$1,000 - $1,500	$1,000 - $3,000	Estimate from other sites
4.02	Site set-up (secondary containment, decon pad, H&S Equipment)	1 - 2	LS	$28,800 - $35,000	$28,800 - $70,000	Estimate from other sites
4.03	Fork-lift	1 - 1	LS	$2,875 - $2,875	$2,875 - $2,875	Quote in D-1
4.04	Waste management	5 - 10	LS	$500 - $1,000	$2,500 - $10,000	Quote in D-1
4.05	Injection oversight	1 - 1	LS	$219,632 - $219,632	$219,632 - $219,632	Estimate from other sites
4.06	Amendments (nZVI)	10,080 - 15,120	POUNDS	$35 - $35	$352,800 - $529,200	Crane Co. price
4.07	Amendments (ZVI with nZVI)	110,215 - 110,215	POUNDS	$0.47 - $0.47	$52,077 - $52,077	Quote in D-4
4.08	Amendments (ZVI)	330,645 - 330,645	POUNDS	$0.47 - $0.47	$156,230 - $156,230	Quote in D-4
4.09	Amendments (bioaugmentation culture)	1,440 - 1,440	LITERS	$200 - $200	$288,000 - $288,000	Quote in D-3
4.10	Amendments (oil)	1 - 1	LS	$73,631 - $73,631	$73,631 - $73,631	Quote in D-3

TABLE D4a
Feasibility Screening Results
Phoenix-Goodyear Airport-North Superfund Site
Goodyear, Arizona

ESTIMATE OF PROBABLE COST

nZVI + ZVI + ARD + Hydraulic Barrier (Alternative 4)

NO.	ITEM	ESTIMATED QTY RANGE	UNIT (EA, LF, LS)	UNIT PRICE RANGE	ESTIMATED COST RANGE	COST SOURCE
4.11	Injections	72 - 72	PER LIFT	$3,399 - $3,399	$244,728 - $244,728	Estimate from other sites
4.12	Analytical suite (standard TAT)	42 - 42	SUITE	$621 - $621	$26,082 - $26,082	Quote in D-1
4.13	Data validation	1 1	LS	$5,000 $5,000	$5,000 $5,000	Estimate from other sites
4.14	Reporting and meetings	1 - 1	LS	$62,168 - $62,168	$62,168 - $62,168	Estimate from other sites
		Year 1 Site Set-up and Injection Activities Subtotal:			***$1,515,500 - $1,742,600***	
5.00	**Year 2 Site Set-up and Injection Activities**					
5.01	Survey	1 - 2	DAY	$1,000 - $1,500	$1,000 - $3,000	Estimate from other sites
5.02	Site set-up (secondary containment, decon pad, H&S Equipment)	1 - 2	LS	$28,800 - $35,000	$28,800 - $70,000	Estimate from other sites
5.03	Fork-lift	1 - 1	LS	$2,875 - $2,875	$2,875 - $2,875	Quote in D-1
5.04	Waste management	5 - 10	LS	$500 - $1,000	$2,500 - $10,000	Quote in D-1
5.05	Injection oversight	1 - 1	LS	$219,632 - $219,632	$219,632 - $219,632	Estimate from other sites
5.06	Amendments (nZVI)	63,840 - 95,760	POUNDS	$35 - $35	$2,234,400 - $3,351,600	Crane Co. price
5.07	Amendments (ZVI with nZVI)	726,750 - 726,750	POUNDS	$0.47 - $0.47	$343,389 - $343,389	Quote in D-4
5.08	Amendments (ZVI)	0 - 0	POUNDS	$0.47 - $0.47	$0 - $0	Quote in D-4
5.09	Amendments (bioaugmentation culture)	2,320 - 2,320	LITERS	$200 - $200	$464,000 - $464,000	Quote in D-3
5.10	Amendments (oil)	1 - 1	LS	$118,627 - $118,627	$118,627 - $118,627	Quote in D-3
5.11	Injections	116 - 116	PER LIFT	$3,399 - $3,399	$394,284 - $394,284	Estimate from other sites
5.12	Analytical suite (standard TAT)	42 - 42	SUITE	$621 - $621	$26,082 - $26,082	Quote in D-1
5.13	Data validation	1 1	LS	$5,000 $5,000	$5,000 $5,000	Estimate from other sites
5.14	Reporting and meetings	1 - 1	LS	$62,168 - $62,168	$62,168 - $62,168	Estimate from other sites
		Year 2 Site Set-up and Injection Activities Subtotal:			***$3,902,800 - $5,070,700***	
6.00	**Year 3 Site Set-up and Injection Activities**					
6.01	Survey	1 - 2	DAY	$1,000 - $1,500	$1,000 - $3,000	Estimate from other sites
6.02	Site set-up (secondary containment, decon pad, H&S Equipment)	1 - 2	LS	$28,800 - $35,000	$28,800 - $70,000	Estimate from other sites
6.03	Fork-lift	1 - 1	LS	$2,875 - $2,875	$2,875 - $2,875	Quote in D-1
6.04	Waste management	5 - 10	LS	$500 - $1,000	$2,500 - $10,000	Quote in D-1
6.05	Injection oversight	1 - 1	LS	$219,632 - $219,632	$219,632 - $219,632	Estimate from other sites
6.06	Amendments (nZVI)	6,720 - 10,080	POUNDS	$35 - $35	$235,200 - $352,800	Crane Co. price
6.07	Amendments (ZVI with nZVI)	57,000 - 57,000	POUNDS	$0.47 - $0.47	$26,933 - $26,933	Quote in D-4
6.08	Amendments (ZVI)	114,000 - 114,000	POUNDS	$0.47 - $0.47	$53,865 - $53,865	Quote in D-4
6.09	Injections	36 - 36	PER LIFT	$3,399 - $3,399	$122,364 - $122,364	Estimate from other sites
6.10	Analytical suite (standard TAT)	42 - 42	SUITE	$621 - $621	$26,082 - $26,082	Quote in D-1
6.11	Data validation	1 1	LS	$5,000 $5,000	$5,000 $5,000	Estimate from other sites
6.12	Reporting and meetings	1 - 1	LS	$62,168 - $62,168	$62,168 - $62,168	Estimate from other sites
		Year 3 Site Set-up and Injection Activities Subtotal:			***$786,400 - $954,700***	
7.00	**Year 4 Site Set-up and Injection Activities**					
7.01	Survey	1 - 2	DAY	$1,000 - $1,500	$1,000 - $3,000	Estimate from other sites
7.02	Site set-up (secondary containment, decon pad, H&S Equipment)	1 - 2	LS	$28,800 - $35,000	$28,800 - $70,000	Estimate from other sites
7.03	Fork-lift	1 - 1	LS	$2,875 - $2,875	$2,875 - $2,875	Quote in D-1
7.04	Waste management	5 - 10	LS	$500 - $1,000	$2,500 - $10,000	Quote in D-1
7.05	Injection oversight	1 - 1	LS	$219,632 - $219,632	$219,632 - $219,632	Estimate from other sites

TABLE D4a
Feasibility Screening Results
Phoenix-Goodyear Airport-North Superfund Site
Goodyear, Arizona

ESTIMATE OF PROBABLE COST

nZVI + ZVI + ARD + Hydraulic Barrier (Alternative 4)

NO.	ITEM	ESTIMATED QTY RANGE	UNIT (EA, LF, LS)	UNIT PRICE RANGE	ESTIMATED COST RANGE	COST SOURCE
7.06	Amendments (nZVI)	1,680 - 2,520	POUNDS	$35 - $35	$58,800 - $88,200	Crane Co. price
7.07	Amendments (ZVI with nZVI)	14,250 - 14,250	POUNDS	$0.47 - $0.47	$6,733 - $6,733	Quote in D-4
7.08	Amendments (ZVI)	85,500 - 85,500	POUNDS	$0.47 - $0.47	$40,399 - $40,399	Quote in D-4
7.09	Injections	27 - 27	PER LIFT	$3,399 - $3,399	$91,773 - $91,773	Estimate from other sites
7.10	Analytical suite (standard TAT)	42 - 42	SUITE	$621 - $621	$26,082 - $26,082	Quote in D-1
7.11	Data validation	1 1	LS	$5,000 $5,000	$5,000 $5,000	Estimate from other sites
7.12	Reporting and meetings	1 - 1	LS	$62,168 - $62,168	$62,168 - $62,168	Estimate from other sites
				Year 4 Site Set-up and Injection Activities Subtotal:	***$545,800 - $625,900***	
8.00	**Year 5 Site Set-up and Injection Activities**					
8.01	Survey	1 - 2	DAY	$1,000 - $1,500	$1,000 - $3,000	Estimate from other sites
8.02	Site set-up (secondary containment, decon pad, H&S Equipment)	1 - 2	LS	$28,800 - $35,000	$28,800 - $70,000	Estimate from other sites
8.03	Fork-lift	1 - 1	LS	$2,875 - $2,875	$2,875 - $2,875	Quote in D-1
8.04	Injection oversight	1 - 1	LS	$219,632 - $219,632	$219,632 - $219,632	Estimate from other sites
8.05	Amendments (nZVI)	6,720 - 10,080	POUNDS	$35 - $35	$235,200 - $352,800	Crane Co. price
8.06	Amendments (ZVI with nZVI)	82,828 - 82,828	POUNDS	$0.47 - $0.47	$39,136 - $39,136	Quote in D-4
8.06	Amendments (ZVI)	82,828 - 82,828	POUNDS	$0.47 - $0.47	$39,136 - $39,136	Quote in D-4
8.07	Amendments (bioaugmentation culture)	480 - 480	LITERS	$200 - $200	$96,000 - $96,000	Quote in D-3
8.08	Amendments (oil)	1 - 1	LS	$24,544 - $24,544	$24,544 - $24,544	Quote in D-3
8.09	Injections	24 - 24	PER LIFT	$3,399 - $3,399	$81,576 - $81,576	Estimate from other sites
8.10	Analytical suite (standard TAT)	42 - 42	SUITE	$621 - $621	$26,082 - $26,082	Quote in D-1
8.11	Data validation	1 - 1	LS	$5,000 $5,000	$5,000 $5,000	Estimate from other sites
8.12	Reporting and meetings	1 - 1	LS	$62,168 - $62,168	$62,168 - $62,168	Estimate from other sites
				Year 5 Site Set-up and Injection Activities Subtotal:	***$861,100 - $1,021,949***	
				CONSTRUCTION AND MATERIALS COST SUBTOTAL (TASKS 1-8):	**$9,344,900 - $11,294,100**	
9.00	**Years 6-8 Performance Monitoring**					
9.01	Long-term monitoring and analytical costs	1 - 1	YR	$145,431 - $145,431	$145,431 - $145,431	Estimate from other sites
9.02	Reporting	1 - 1	YR	$132,268 - $132,268	$132,268 - $132,268	Estimate from other sites
				Years 6-8 Performance Monitoring Subtotal:	***$277,700 - $277,700***	
				NPV for O&M:	***$820,800 - $820,800***	
				O&M COST SUBTOTAL (TASK 9):	**$820,800 - $820,800**	
10.00	**Closure Costs**					
10.01	Abandon injection wells	45 - 45	WELL	$1,850 - $2,565	$83,250 - $115,425	Quote in D-1
10.02	Abandon groundwater wells	11 - 11	WELL	$1,760 - $2,475	$19,360 - $27,225	Quote in D-1
10.03	Solid waste disposal	28 - 56	BIN	$500 - $750	$14,000 - $42,000	Quote in D-1
10.04	Site restoration	1 - 1	LS	$25,000 - $50,000	$25,000 - $50,000	Estimate from other sites
10.05	Oversight	1 - 1	LS	$120,000 - $120,000	$120,000 - $120,000	Estimate from other sites
10.06	Reporting and meetings	1 - 1	LS	$60,000 - $100,000	$60,000 - $100,000	Estimate from other sites
				CLOSURE COST SUBTOTAL (TASK 10):	**$321,610 - $454,650**	
				TOTAL COST (BARE):	**$10,487,310 - $12,569,550**	
				AVERAGE COST (BARE):	**$11,528,400**	
				TOTAL COST WITH -30% TO +50% CONTINGENCY:	**$8,069,900 - $17,292,600**	

TABLE D4b - IRON DOSES YEARS 1 THROUGH 5
Feasibility Screening Results
Phoenix-Goodyear Airport-North Superfund Site
Goodyear, Arizona

IRON DOSE CALCULATIONS
SUMMARY TABLE

Amendment	Year 1 (pounds)	Year 2 (pounds)	Year 3 (pounds)	Year 4 (pounds)	Year 5 (pounds)	Total (Years 1 through 5)
nZVI - 40%[1]	10,080	63,840	6,720	1,680	6,720	89,040
nZVI - 60%[1]	15,120	95,760	10,080	2,520	10,080	133,560
ZVI[2] (in addition to nZVI)	110,215	726,750	57,000	14,250	82,828	991,043
ZVI[2]	330,645	0	114,000	85,500	82,828	612,973

NOTES:

1 This dosage is based on a percentage of the original pilot test dose of 1,400 pounds of nZVI per lift.

2 This dosage is base upon a soil demand ratio of 0.004 ZVI to soil by weight.

PEERLESS™

PMP ZERO VALENT IRON AGGREGATE SIZE 50D

TYPICAL 15 MINUTE ROTAP

SCREEN SIZE	% RETAINED
45	0
60	0
80	14
100	10
200	29
325	18
PAN	29
	100

TYPICAL BULK DENSITY RANGE 145 – 195 POUNDS PER CUBIC FOOT

PMP IRON AGGREGATES ARE 100% DRY AND OIL FREE

TYPICAL CHEMISTRY:

Element	Percentage
Iron	90+
Carbon	1.5 – 2.5
Silicon	2.00
Manganese	0.60
Sulfur	0.12
Phosphorus	0.14
Nickel	0.20
Chromium	0.20
Molybdenum	0.15
Copper	0.20

January, 2011

Peerless Metal Powders & Abrasive

124 South Military • Detroit, Michigan 48209
(313) 841-5400 Fax (313) 841-0240

From:	Noreen Warrens
To:	Bell, Suzanne
Subject:	FW: Microscale Zero Valent Iron Pricing
Date:	Tuesday, August 28, 2012 10:24:02 AM
Attachments:	scan1024.pdf

Suzanne, I sent this spec to you on 8/23, does it work for you?

Budgetary pricing for this 50D material is ---- $800/per net ton plus $17/per net ton for packaging in 3000# bulk bags, palletized. F.O.B. Detroit, MI. Terms are non refundable 30% deposit with the order and prepayment a minimum of 1 week prior to shipment.

Please let me know if you have any additional questions,

Thank you,

Noreen Warrens
Peerless Metal Powders
Nwarrens@peerlessmetal.com
313-841-5400

-----Original Message-----
From: Noreen Warrens [mailto:nwarrens@peerlessmetal.com]
Sent: Thursday, August 23, 2012 3:10 PM
To: 'Bell, Suzanne'
Subject: RE: Microscale Zero Valent Iron Pricing

Suzanne,

I have attached the typical specs on the finest size iron we produce. If that is something you can use I will be happy to quote you pricing.

Regards,
Noreen

-----Original Message-----
From: Bell, Suzanne [mailto:SBell@HaleyAldrich.com]
Sent: Wednesday, August 22, 2012 4:04 PM
To: nwarrens@peerlessmetal.com
Subject: RE: Microscale Zero Valent Iron Pricing

Hi Noreen,

Thanks for the quick reply. We can use a size range of 50 - 200 microns.

Thanks again,
Suzanne

From: Noreen Warrens [nwarrens@peerlessmetal.com]
Sent: Wednesday, August 22, 2012 1:01 PM
To: Bell, Suzanne
Subject: RE: Microscale Zero Valent Iron Pricing

Hello Suzanne,

Iron prices fluctuate but I would be happy to give you some budgetary pricing.   What sieve size (micron size range) do you require?

Regards,

Noreen Warrens
Peerless Metal Powders
Nwarrens@peerlessmetal.com
313-841-5400

-----Original Message-----
From: Bell, Suzanne [mailto:SBell@HaleyAldrich.com]
Sent: Wednesday, August 22, 2012 2:53 PM
To: nwarrens@peerlessmetal.com
Subject: Microscale Zero Valent Iron Pricing

Hello Noreen,

I was given your contact information from Paula Chang at Haley & Aldrich and I'm hoping to get a price estimate for ZVI. We are working on a feasibility study to remediate chlorinated solvents and would be injecting micron range ZVI powder. The design isn't final, but at this point, the amount of ZVI could range anywhere from about 110,000 pounds to 2,000,000 pounds.

Do have a price per pound available for those amounts? Do they change based on the quantity ordered? Also, please provide any shipping costs. The site is located in Phoenix, AZ.

Please let me know if you need any more information.

Thank you,

Suzanne M. Bell
Staff Scientist, E.I.T.
HALEY & ALDRICH
600 S. Meyer Ave
Tucson, AZ 85701-2554
Office: 520.289.8607
Cell: 520.975.3899
Fax: 520.289.8657
sbell@haleyaldrich.com<mailto:sbell@haleyaldrich.com>
HaleyAldrich.com<http://www.haleyaldrich.com>

D5 – Alternative 5
ZVI + ARD + Hydraulic Barrier

TABLE D5a
Feasibility Screening Results
Phoenix-Goodyear Airport-North Superfund Site
Goodyear, Arizona

ESTIMATE OF PROBABLE COST

ZVI + ARD + Hydraulic Barrier (Alternative 5)

NO.	ITEM	ESTIMATED QTY RANGE	UNIT (EA, LF, LS)	UNIT PRICE RANGE	ESTIMATED COST RANGE	COST SOURCE
1.00	**Permits, Design, and Work Plan**					
1.01	Health & Safety Plan	1 - 1	LS	$10,000 - $10,000	$10,000 - $10,000	Estimate from other sites
1.02	Underground Injection Control Permit	1 - 1	LS	$10,000 - $15,000	$10,000 - $15,000	Estimate from other sites
1.03	Bench-scale testing for bio	1 - 1	LS	$20,000 - $30,000	$20,000 - $30,000	Estimate from other sites
1.04	Permits, design, office support	1 - 1	LS	$80,062 - $80,062	$80,062 - $80,062	Estimate from other sites
1.05	Work Plan and Report	1 - 1	LS	$69,233 - $69,233	$69,233 - $69,233	Estimate from other sites
		Permits, Design, and Work Plan Subtotal:			***$189,300 - $204,300***	
2.00	**Full Scale Mobilization/Demobilization**					
2.01	Injection Contractor	528 - 528	LIFT	$2,000 - $2,000	$1,056,000 - $1,056,000	Quote in D-1
2.02	Drilling Contractor	1 - 1	LS	$1,500 - $3,000	$1,500 - $3,000	Quote in D-1
2.03	Fencing	5 - 5	LS	$2,300 - $2,300	$11,500 - $11,500	Quote in D-1
2.04	Aboveground piping installation from MTS	0 - 0	FT	$7 - $10	$0 - $0	NA
2.05	Secondary containment	25 - 30	MO	$500 - $1,000	$12,500 - $30,000	Quote in D-1
2.06	Tank rental and misc equipment	5 - 10	MO	$1,500 - $2,000	$7,500 - $20,000	Quote in D-1
		Full Scale Mobilization/Demobilization Subtotal:			***$1,089,000 - $1,120,500***	
3.00	**Injection and Monitoring Well Installation**					
3.01	Survey	2 - 3	DAY	$1,000 - $1,500	$2,000 - $4,500	Estimate from other sites
3.02	Driller installation, development of monitoring wells	12 - 12	WELL	$16,050 - $16,050	$192,600 - $192,600	Quote in D-1
3.03	Driller installation, development of permanent injection wells	96 - 96	WELL	$15,250 - $15,250	$1,464,000 - $1,464,000	Quote in D-1
3.04	YR 1 distribution coring	1 - 1	LS	$72,166 - $72,166	$72,166 - $72,166	Quote in D-1
3.05	Solid waste disposal	96 - 105	BIN	$500 - $750	$48,000 - $78,750	Quote in D-1
3.06	Connection to MTS for provision of treated water to source area	1 - 1	LS	$75,000 - $125,000	$75,000 - $125,000	Estimate from other sites
3.07	Analytical lab (24-hour TAT)	96 - 96	SAMPLE	$120 - $120	$11,520 - $11,520	Quote in D-1
3.08	Analytical lab (standard TAT)	0 - 0	SUITE	$621 $621	$0 $0	Quote in D-1
3.09	Oversight	1 - 1	LS	$84,418 - $84,418	$84,418 - $84,418	Estimate from other sites
3.10	Baseline sampling	108 - 108	WELL	$800 - $1,200	$86,400 - $129,600	Quote in D-1
		Injection and Monitoring Well Installation Subtotal:			***$2,036,100 - $2,162,600***	
4.00	**Year 1 Site Set-up and Injection Activities**					
4.01	Survey	2 - 3	DAY	$1,000 - $1,500	$2,000 - $4,500	Estimate from other sites
4.02	Site set-up (secondary containment, decon pad, H&S Equipment)	1 - 2	LS	$28,800 - $35,000	$28,800 - $70,000	Estimate from other sites
4.03	Fork-lift	1 - 1	LS	$2,875 - $2,875	$2,875 - $2,875	Quote in D-1
4.04	Waste management	5 - 10	LS	$500 - $1,000	$2,500 - $10,000	Quote in D-1
4.05	Injection oversight	1 - 1	LS	$219,632 - $219,632	$219,632 - $219,632	Estimate from other sites
4.06	Amendments (EHC)	360,000 - 360,000	POUNDS	$2 - $2	$709,200 - $709,200	Quote in D-5
4.07	Amendments (bioaugmentation culture)	4,800 - 4,800	LITERS	$200 - $200	$960,000 - $960,000	Quote in D-3
4.08	Injections	240 - 240	PER LIFT	$3,399 - $3,399	$815,760 - $815,760	Estimate from other sites

TABLE D5a
Feasibility Screening Results
Phoenix-Goodyear Airport-North Superfund Site
Goodyear, Arizona

ESTIMATE OF PROBABLE COST

ZVI + ARD + Hydraulic Barrier (Alternative 5)

NO.	ITEM	ESTIMATED QTY RANGE	UNIT (EA, LF, LS)	UNIT PRICE RANGE	ESTIMATED COST RANGE	COST SOURCE
4.09	Analytical suite (standard TAT)	42 - 42	SUITE	$621 - $621	$26,082 - $26,082	Quote in D-1
4.10	Data validation	1 - 1	LS	$5,000 $5,000	$5,000 $5,000	Estimate from other sites
4.11	Reporting and meetings	1 - 1	LS	$62,168 - $62,168	$62,168 - $62,168	Estimate from other sites
				Year 1 Site Set-up and Injection Activities Subtotal:	***$2,834,000 - $2,885,200***	
5.00	**Year 2 Site Set-up and Injection Activities**					
5.01	Survey	2 - 3	DAY	$1,000 - $1,500	$2,000 - $4,500	Estimate from other sites
5.02	Site set-up (secondary containment, decon pad, H&S Equipment)	1 - 2	LS	$28,800 - $35,000	$28,800 - $70,000	Estimate from other sites
5.03	Fork-lift	1 - 1	LS	$2,875 - $2,875	$2,875 - $2,875	Quote in D-1
5.04	Waste management	5 - 10	LS	$500 - $1,000	$2,500 - $10,000	Quote in D-1
5.05	Injection oversight	1 - 1	LS	$219,632 - $219,632	$219,632 - $219,632	Estimate from other sites
5.06	Amendments (EHC)	216,000 - 216,000	POUNDS	1.97 - 1.97	$425,520 - $425,520	Quote in D-5
5.07	Amendments (bioaugmentation culture)	2,880 - 2,880	LITERS	$200 - $200	$576,000 - $576,000	Quote in D-3
5.08	Injections	144 - 144	PER LIFT	$3,399 - $3,399	$489,456 - $489,456	Estimate from other sites
5.09	Analytical suite (standard TAT)	42 - 42	SUITE	$621 - $621	$26,082 - $26,082	Quote in D-1
5.10	Data validation	1 - 1	LS	$5,000 $5,000	$5,000 $5,000	Estimate from other sites
5.11	Reporting and meetings	1 - 1	LS	$62,168 - $62,168	$62,168 - $62,168	Estimate from other sites
				Year 2 Site Set-up and Injection Activities Subtotal:	***$1,840,000 - $1,891,200***	
6.00	**Year 3 Site Set-up and Injection Activities**					
6.01	Survey	2 - 3	DAY	$1,000 - $1,500	$2,000 - $4,500	Estimate from other sites
6.02	Site set-up (secondary containment, decon pad, H&S Equipment)	1 - 2	LS	$28,800 - $35,000	$28,800 - $70,000	Estimate from other sites
6.03	Fork-lift	1 - 1	LS	$2,875 - $2,875	$2,875 - $2,875	Quote in D-1
6.04	Waste management	5 - 10	LS	$500 - $1,000	$2,500 - $10,000	Quote in D-1
6.05	Injection oversight	1 - 1	LS	$219,632 - $219,632	$219,632 - $219,632	Estimate from other sites
6.06	Amendments (EHC)	108,000 - 108,000	POUNDS	$2 - $2	$212,760 - $212,760	Quote in D-5
6.07	Amendments (bioaugmentation culture)	1,440 - 1,440	LITERS	$200 - $200	$288,000 - $288,000	Quote in D-3
6.08	Injections	72 - 72	PER LIFT	$3,399 - $3,399	$244,728 - $244,728	Estimate from other sites
6.09	Analytical suite (standard TAT)	42 - 42	SUITE	$621 - $621	$26,082 - $26,082	Quote in D-1
6.10	Data validation	1 - 1	LS	$5,000 $5,000	$5,000 $5,000	Estimate from other sites
6.11	Reporting and meetings	1 - 1	LS	$62,168 - $62,168	$62,168 - $62,168	Estimate from other sites
				Year 3 Site Set-up and Injection Activities Subtotal:	***$1,094,500 - $1,145,700***	
7.00	**Year 4 Site Set-up and Injection Activities**					
7.01	Survey	2 - 3	DAY	$1,000 - $1,500	$2,000 - $4,500	Estimate from other sites
7.02	Site set-up (secondary containment, decon pad, H&S Equipment)	1 - 2	LS	$28,800 - $35,000	$28,800 - $70,000	Estimate from other sites
7.03	Fork-lift	1 - 1	LS	$2,875 - $2,875	$2,875 - $2,875	Quote in D-1
7.04	Waste management	5 - 10	LS	$500 - $1,000	$2,500 - $10,000	Quote in D-1
7.05	Injection oversight	1 - 1	LS	$219,632 - $219,632	$219,632 - $219,632	Estimate from other sites
7.06	Amendments (EHC)	108,000 - 108,000	POUNDS	$2 - $2	$212,760 - $212,760	Quote in D-5

TABLE D5a
Feasibility Screening Results
Phoenix-Goodyear Airport-North Superfund Site
Goodyear, Arizona

ESTIMATE OF PROBABLE COST

ZVI + ARD + Hydraulic Barrier (Alternative 5)

NO.	ITEM	ESTIMATED QTY RANGE	UNIT (EA, LF, LS)	UNIT PRICE RANGE	ESTIMATED COST RANGE	COST SOURCE
7.07	Amendments (bioaugmentation culture)	1,440 - 1,440	LITERS	$200 - $200	$288,000 - $288,000	Quote in D-3
7.08	Injections	72 - 72	PER LIFT	$3,399 - $3,399	$244,728 - $244,728	Estimate from other sites
7.09	Analytical suite (standard TAT)	42 - 42	SUITE	$621 - $621	$26,082 - $26,082	Quote in D-1
7.10	Data validation	1 - 1	LS	$5,000 $5,000	$5,000 $5,000	Estimate from other sites
7.11	Reporting and meetings	1 - 1	LS	$62,168 - $62,168	$62,168 - $62,168	Estimate from other sites
		Year 4 Site Set-up and Injection Activities Subtotal:			***$1,094,500 - $1,145,700***	
8.00	**Year 5 Site Set-up and Injection Activities**					
8.01	Survey	2 - 3	DAY	$1,000 - $1,500	$2,000 - $4,500	Estimate from other sites
8.02	Site set-up (secondary containment, decon pad, H&S Equipment)	1 - 2	LS	$28,800 - $35,000	$28,800 - $70,000	Estimate from other sites
8.03	Fork-lift	1 - 1	LS	$2,875 - $2,875	$2,875 - $2,875	Quote in D-1
8.04	Injection oversight	1 - 1	LS	$219,632 - $219,632	$219,632 - $219,632	Estimate from other sites
8.05	Amendments (EHC)	81,000 - 81,000	POUNDS	$2 - $2	$159,570 - $159,570	Quote in D-5
8.06	Amendments (bioaugmentation culture)	1,080 - 1,080	LITERS	$200 - $200	$216,000 - $216,000	Quote in D-3
8.07	Injections	54 - 54	PER LIFT	$3,399 - $3,399	$183,546 - $183,546	Estimate from other sites
8.08	Analytical suite (standard TAT)	42 - 42	SUITE	$621 - $621	$26,082 - $26,082	Quote in D-1
8.09	Data validation	1 - 1	LS	$5,000 $5,000	$5,000 $5,000	Estimate from other sites
8.10	Reporting and meetings	1 - 1	LS	$62,168 - $62,168	$62,168 - $62,168	Estimate from other sites
		Year 5 Site Set-up and Injection Activities Subtotal:			***$905,700 - $949,400***	
	CONSTRUCTION AND MATERIALS COST SUBTOTAL (TASKS 1-8):				**$11,083,100 - $11,504,600**	
9.00	**Years 6-11 Performance Monitoring**					
9.01	Long-term monitoring and analytical costs	1 - 1	YR	$145,431 - $145,431	$145,431 - $145,431	Estimate from other sites
9.02	Reporting	1 - 1	YR	$132,268 - $132,268	$132,268 - $132,268	Estimate from other sites
		Years 6-11 Performance Monitoring Subtotal:			***$277,700 - $277,700***	
				NPV for O&M:	***$1,357,800 - $1,357,800***	
	O&M COST SUBTOTAL (TASK 9):				**$1,357,800 - $1,357,800**	
10.00	**Closure Costs**					
10.01	Abandon injection wells	96 - 96	WELL	$1,850 - $2,565	$177,600 - $246,240	Quote in D-1
10.02	Abandon groundwater wells	12 - 12	WELL	$1,760 - $2,475	$21,120 - $29,700	Quote in D-1
10.03	Solid waste disposal	54 - 108	BIN	$500 - $750	$27,000 - $81,000	Quote in D-1
10.04	Site restoration	1 - 1	LS	$25,000 - $50,000	$25,000 - $50,000	Estimate from other sites
10.05	Oversight	1 - 1	LS	$120,000 - $120,000	$120,000 - $120,000	Estimate from other sites
10.06	Reporting and meetings	1 - 1	LS	$60,000 - $100,000	$60,000 - $100,000	Estimate from other sites
	CLOSURE COST SUBTOTAL (TASK 10):				**$430,720 - $626,940**	
		TOTAL COST (BARE):			**$12,871,620 - $13,489,340**	
		AVERAGE COST (BARE):			**$13,180,480**	
	TOTAL COST WITH -30% TO +50% CONTINGENCY:				**$9,226,336 - $19,770,720**	

TABLE D5b
Source Zone Treatment

Client Name: Haley & Aldrich
Project Location: Goodyear, AZ
Proposal Number: AAI11-683

Units

Soil Data

Calculated soil dry bulk density	125	lbs/ft3 bulk soil
Total porosity	24%	

EHC Application Rate

Percentage EHC by mass in entire plume	0.07%	

Plume Dimensions

Length of plume/treatment zone	700	ft
Width of plume/treatment zone	220	ft
Depth to top of treatment zone	90	ft
Depth to bottom of treatment zone	150	ft
Treatment zone thickness	60	ft

EHC Requirement

Total mass of soil in treatment zone	577,500	U.S. tons
Total mass of EHC Required:	404.3	U.S. tons
Total mass of EHC Required:	808,500	lbs
Total mass of EHC required (rounded to ship size)	808,500	lbs
Unit cost of EHC	$1.50	
Total cost of EHC:	**$1,212,750**	USD
Small order handling fee	$0	USD

Number of Injection Points

Spacing between injection lines	150	ft
Spacing between injection points within lines	16	ft
Vertical spacing between injection layers	3	ft
Number of injection lines required	5	lines
Number of points per line	14	points/line
Total number of injection points	70	points
Number of layers per point	20	layers/point

Preparation of EHC Slurry

EHC formula		
Concentration of EHC slurry to inject	5%	by weight
Total volume of water required	1,843,380	U.S. gallons
Approximate density of solution to inject	8.40	lbs/USG
Approximate volume of solution to inject	1,925,000	U.S. gallons

Injection Details

Mass EHC injected per injection point	11550	lbs
Mass EHC injected per layer	578	lbs
Mass EHC injected per vertical foot	193	lbs/ft
Volume EHC injected per injection point	27500	U.S. gallons
Volume EHC injected per layer	1375	U.S. gallons

Estimated Shipping Costs

Rough estimate for purpose of proposals	**$50,000**	Applicable within USA only

From:	Doug Knight
To:	Chang, Paula; Tsiatsios, Chris
Subject:	FW: FRx
Date:	Monday, October 31, 2011 10:42:13 AM

Paula/Chris,

ZVI supplier contact information below.

$450 to $550 per ton. (half price from my experience)

Sieve sized 80/120.

Good quality product from my, contractor, perspective.

We have put 100s of tons in the ground.

Chemical reactivity quality unknown to me, but product has been tested and used by Adventus.

Cheers,

Doug

Doug Knight
Operations Manager, FRx, Inc.
Greenville, SC
Phone: 864-356-8424
Fax: 877-450-5807

Mike Dresser
GMA Industries
734-891-4608 cell
mdresser@gmaind.com
www.gmaind.com

Via Email: CTsiatsios@haleyaldrich.com

November 8, 2011

EHC®
The Original Injectable ISCR Reagent for Groundwater Applications

Chris Tsiatsios
Senior Engineer
Haley & Aldrich, Inc.
3187 Red Hill Avenue, Suite 155
Costa Mesa, CA 92626-3410
Telephone 714-371-1820

Subject: Treatment of CVOCs using ISCR Technology
PGA-North Site – Phoenix, AZ
Adventus Proposal No. AAI11-683

Dear Mr. Tsiatsios:

Please find herewith a conceptual remedial design and cost estimate for employing EHC® *in situ* chemical reduction (ISCR™) technology to remove chlorinated volatile organic compounds (CVOCs) from groundwater at the above referenced site (the Site). The cost estimate includes EHC amendments and delivery (estimated); Adventus on-site field support for the initiation of the project is presented as a recommended option.

In developing this proposal, Adventus recognizes that we may have received potentially sensitive data and confidential information. Since our inception, Adventus has always maintained client files in confidence and we will preserve the confidentiality of sensitive data and confidential information received in developing our proposal.

TECHNOLOGY BACKGROUND

EHC® is the original, patented combination of controlled-release carbon and zero valent iron (ZVI) particles used for stimulating *in situ* chemical reduction (ISCR) of otherwise persistent organic compounds in groundwater. Variations of these materials have been used to treat over 9,000,000 tons of soil/sediment impacted by recalcitrant compounds as part of the company's DARAMEND® bioremediation technology. Both EHC and DARAMEND are proven, established technologies that have been used at hundreds of sites to date throughout the world. The technologies have been accepted and many Federal, State and regional regulatory authorities within the USA/Canada (**Figure 1a**) Europe (**Figure 1b**) and other places around the world.

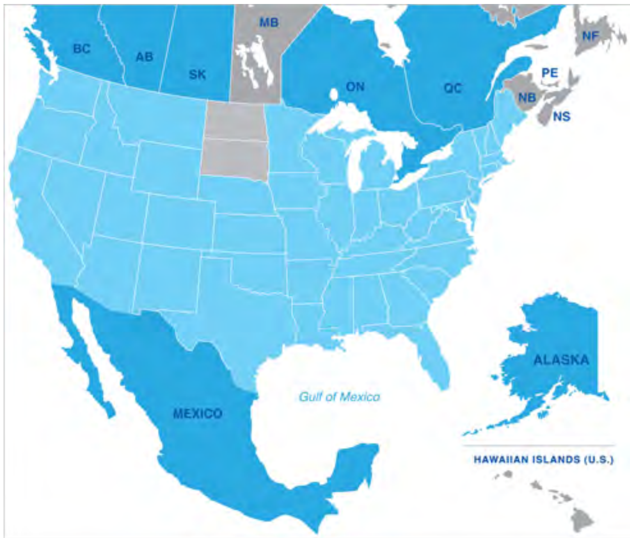


Figure 1a. Adventus Projects - North America
5 Provinces, 48 States > 2,000 projects

Figure 1b. Adventus Projects – "Europe"
17 Countries ca. 100 projects

EHC is available as a **solid or liquid** material that can be easily injected into the subsurface environment in a variety of ways, based on site-specific designs. Application methods include direct mixing, hydraulic fracturing, pneumatic fracturing, and injection of slurries or liquids. Direct placement in trenches and excavations are also reliable application methods.

Following placement of EHC into the subsurface environment, a number of physical, chemical and microbiological processes combine to create very strong reducing conditions that stimulate rapid and complete dechlorination of organic solvents and other recalcitrant compounds. First, the organic component of EHC (fibrous organic material) is nutrient rich, **hydrophilic** and has high surface area; thus, it is an ideal support for growth of bacteria in the groundwater environment. As they grow on EHC particle surfaces, indigenous heterotrophic bacteria consume dissolved oxygen thereby reducing the redox potential in groundwater. In addition, as the bacteria grow on the organic particles, they ferment carbon and release a variety of volatile fatty acids (acetic, propionic, butyric) which diffuse from the site of fermentation into the groundwater plume and serve as electron donors for other bacteria, including dehalogenators and halorespiring species. Finally, the small ZVI particles (ca. <5 to 45 μm) provide substantial reactive surface area that stimulates direct chemical dechlorination and an additional drop in the redox potential of the groundwater via chemical oxygen scavenging.

These physical, chemical and biological processes combine to create an extremely reduced environment that stimulates chemical and microbiological dechlorination of otherwise persistent compounds. Redox potentials as low as –550 mV are commonly observed in groundwater after EHC application. At these Eh levels, many organic constituents of interest (COI) are thermodynamically unstable and they will readily degrade via pathways more typical of physical destruction processes (minimum production and no accumulation of typically recognized biodegradation intermediates such as DCE for TCE). Hence, the ISCR technology is microbiologically based in that we rely on indigenous microbes to biodegrade the EHC carbon (refined plant materials), but we do not require the presence or activity of special or otherwise unique bacteria for complete and effective remediation.

The type of EHC used for a given site depends, in part, on the construction method employed to emplace the material into the subsurface. If a direct mixing or direct placement method is used, the standard slow release, solid EHC material would likely be utilized. If an injection method is used, however, a combination of fast and slow release EHC may be preferred. If the material is to be placed through an existing well network, then a water-soluble, aqueous formulation (EHC-L) may be utilized.

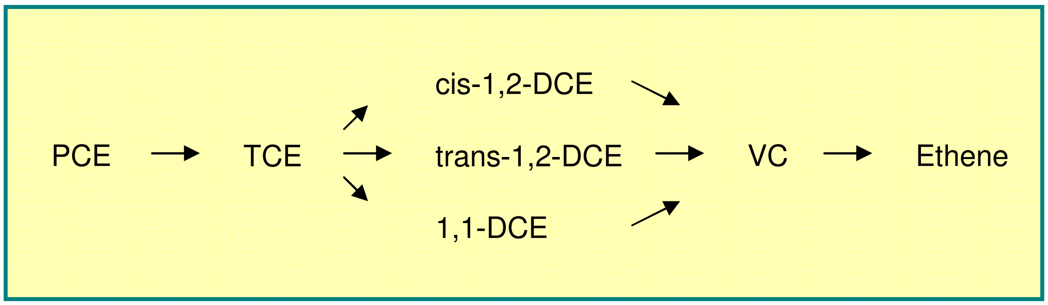
In either event, the fibrous organic carbon and ZVI or other reduced metal that comprises the slow release EHC will remain in the location where it is injected. It will not only treat COI that migrates into the treated area, but it will also have a ‘halo’ or ‘zone of influence’ of low redox conditions that will extend beyond its physical space, greatly increasing its effectiveness. **Figure 2** shows how EHC injection creates a wide zone of influence outside of its immediate location. The native soil color is the yellow visible on the right hand side of the core. The orange discoloration is due to the low redox conditions created by the EHC, which became apparent after exposure to the air for 2 hours.

Figure 2: Photograph of a soil core, from 30 ft to 33 ft bgs, showing a 1-inch seam.

MODE OF ACTION – ISCR FOR CVOCs

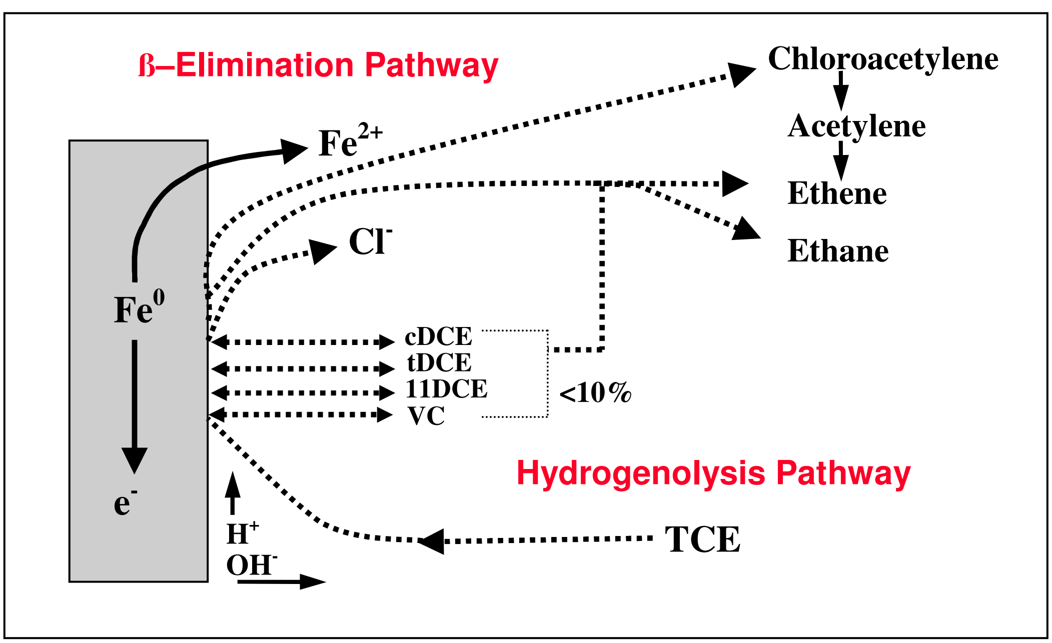
It is critical to understand that the processes of COI destruction under ISCR conditions are different from the typical pathways. The primary COIs in the Site groundwater are PCE/TCE and the recognized daughter products of reductive dehalogenation reactions that occur under normal anaerobic conditions (**Figure 3**).

Figure 3: PCE /TCE Degradation Schematic – Sequential Reductive Dehalogenation under Typical Anaerobic Conditions.



Under ISCR conditions (Eh <-550 mV), these pathways are avoided and terminal destruction / mineralization proceeds along the lines of the recognized *beta*-elimination pathways (**Figure 4**). These differences have been described by various experts in the field of biotransformation processes (*e.g.*, Dr. John Wilson, US EPA as reported in the AFCEE Technology Transfer Seminar, 2003; Dr. Mark Ferry, MPCAA; J, Szecsody and J. Fruchter *et al*., Battelle Pacific Northwest National Laboratory).

Figure 4: PCE /TCE Degradation Schematic – Representative Reactions for Mineralization under ISCR Conditions.



CASE STUDIES

EHC treatment has effectively removed a range of CVOCs under full-scale field conditions without generation of potentially problematic catabolites (**Appendix A**):

- EHC for source area treatment in clayey lithology (PCE and catabolites), Former dry cleaner, Oregon
- EHC-M for isolated hotspot treatment (TCE and Cr(VI)), NW USA
- EHC for source area mass reduction (TCE, TCA and catabolites), Cherry Point, North Carolina
- EHC for complete plume treatment using multiple reactive barriers (CF, TCE and OCPs), Confidential site, Southeast USA
- EHC injection PRB for plume management (CT, CF), confidential site, Kansas
- EHC injection PRB for plume management (cis-DCE and VC), confidential site, Ohio
- EHC trench PRB and excavation backfill (PCE and daughters), confidential site, Texas
- EHC applied via hydraulic fracturing into partially weathered rock, confidential site, Manufacturing facility, North Carolina

EHC has been accepted by the Arizona Department of Environmental Quality and many other regulatory agencies. The product is made in the USA and supplied in 50 lb bags as a powder which can be mixed with soil or slurried in water. Installation techniques vary widely depending on the application. For example, the powder can be mixed with soil and placed at the bottom of an excavation where prior soil removal had been conducted. A slurry can be made and the mixture can be injected into the subsurface using techniques such as direct injection through GeoProbe rods or hydraulic fracturing.

POTENTIAL ADVANTAGES OF USING EHC ISCR TECHNOLOGY

The patented combination of controlled-release organic carbon plus ZVI uniquely yields ISCR conditions which give EHC powerful technical advantages over other materials that provide only carbon (*i.e.*, emulsified oils, molasses or lactate-based substrates) or only ZVI. These include:

- **Health and Safety.** Safe handling and easy application with no bulky or hazardous material disposal issues;
- **Minimal Methane Production**. The presence of ZVI and the complex, controlled-release carbon source help minimize production of potentially problematic fermentation end-products, such as methane;
- **Predictable Performance.** EHC uniquely integrated chemical and microbiological degradation processes which allows treatment to proceed at a predictable rate;

- **Constructability.** EHC is easily and quickly injected using conventional construction technologies;
- **No Mobilization of Contaminants.** Optimal volume of EHC slurry is injected **without the need for extensive water flushing**, which avoids potential displacement and mobilization issues;
- **Accelerated Site Closure** due to the ability of the EHC system to rapidly remove COI mass via a combination of biogeochemical degradation processes **without relying on physical sorption / sequestration as a major "removal" mechanism, ala oils;**
- **ISCR.** Combined chemical and biological oxygen scavenging facilitates rapid oxygen consumption and establishment of reduced Eh; Generation of significantly lowered reducing conditions usually eliminates any requirement for specialty microorganisms or inoculants;
- **No Dead-End Intermediates.** Rapid COI removal without accumulation of potentially problematic catabolites, such as *cis* DCE from TCE or chloroform (CF) from carbon tetrachloride (CT) (see Dolfing *et al*, 2008; Liu *et al*., 2000)
- **Applicability.** Demonstrated effective on a wide range of COI, including chlorinated solvents, Freons, pesticides, perchlorate and other energetic compounds (explosives);
- **Longevity with no Rebound.** EHC remains active in the environmental for 12 to 60 months hence COI rebound phenomena are not observed (rebound is common when using readily biodegradable, liquid substrates);
- **Complete Technology.** Provision of major, minor and micronutrients that are essential to the activity of fastidious anaerobic bacteria involved in recognized dechlorination reactions;
- <u>**Buffering Capacit**</u><u>*y. Provision of substantial pH buffering capacity (i.e., different EHC products are designed to release alkalinity, acidity or to maintain a neutral pH). In contrast, the addition of conventional organic substrates (e.g., emulsified oils, molasses or lactate-based materials) to promote COI biodegradation can lead to aquifer acidification*</u>;
- **Facilitates Natural Attenuation Processes.** For all the reasons summarized above, EHC enhances the natural biological processes. Other technologies may offer short term COI reduction via sorption reactions, etc. but they can alter the environmental conditions such that natural attenuation mechanisms are adversely influenced; and
- **Simultaneous Immobilization of Heavy Metals.** EHC will not mobilize arsenic, and EHC-M will simultaneously immobilize many other heavy metals, which may be present as other potential COIs.

UNDERSTANDING SITE CONDITIONS AND GOALS

Impacts to soil, soil gas, and groundwater at the Phoenix-Goodyear Airport-North (PGA-North) Superfund Site are being considered in an on-going Feasibility Study. The environmental impacts associated with the PGA-North Site are the result of past disposal practices of waste materials from Site operations into a series of dry wells located in the central portion of the former Unidynamics Phoenix Inc facility (known as the 'Main Drywells Source Area' [MDWSA]). These drywells were approximately 13 feet deep and were installed exclusively within the vadose (soil above groundwater) zone. When the drywells were in use, the waste materials disposed of in them migrated downward, over time, through the vadose zone to the water table as a result of gravity. Following downward migration through the vadose zone, the waste materials entered the groundwater and have since migrated horizontally and vertically into the local aquifer system.

A number of hazardous materials and wastes were used and handled at the UPI site during historical operations. However, following completion of extensive soil and groundwater remedial investigation on Site, it has been determined that the constituents of concern from a remediation perspective are limited to the chlorinated volatile organic compound trichloroethene (TCE) and the inorganic compound perchlorate ($ClO4-$). There are other volatile organic compounds (VOC) listed as Constituents of Concerns in the Consent Decree (CD) for PGA-North. However, TCE is the only VOC at the Site that has been consistently detected at elevated levels in the source area. Site data clearly supports that detections of the VOC tetrachlorethene (PCE) in the area of Site are related to other sites/sources located hydraulically upgradient and to the south of the former UPI facility and MDWSA.

The aquifer lithology is composed of interbedded sands, silty sands, and clayey sands about 160 ft thick. Depth to groundwater is about 80 ft. Groundwater flows at a linear velocity of 1 ft/day. The shallow aquifer is slightly alkaline (pH 7.6) and hypoxic, with a DO of 3.5 mg/L and an ORP of +30 mV. Iron and sulfate levels are high, at 200 mg/L and 875 mg/L, respectively.

The groundwater is impacted by chlorinated solvents constituents of interest (COI), namely TCE and perchlorate. TCE concentrations up to 41,000 ug/L have been observed, with an average concentration of about 1,000 ug/L. Average perchlorate concentrations fall below the remedial target of 14 ug/L but the maximum observed concentrations are at 25 ug/L.

CONCEPTUAL REMEDIAL DESIGN

The EHC ISCR technology has been effectively employed to treat the COIs present at the Site. EHC may be applied in a series of PRBs through the source area to remove COI residuals without the accumulation of dead-end, problematic catabolites.

For conceptual design purposes, five ISCR permeable reactive barrier (PRB) zones will be created throughout the COI impacted area. The PRB units will be spaced approximately 150 feet apart, which represents less than 1 year travel time (**Figure 5**). Each PRB will have a length of 220 ft long x 16 ft wide (diameter of injections) x 60 ft deep (from 90 to 150 ft bgs). EHC will be applied at an average loading rate of 0.07% to soil mass, with a loading rate of 0.61% in the PRBs. This results in a total of 808,500 lbs of EHC applied via 70 injection points spaced ca. 16 feet apart (**Table 1**).

Figure 5: Conceptual Layout of PRBs

Table 1: Estimated EHC requirements and injection details for ISCR PRBs.

	Value	Unit
Treatment Area Dimensions:		
Length of plume/treatment zone	700	ft
Width of plume/treatment zone	220	ft
Depth to top of treatment zone	90	ft
Depth to bottom of treatment zone	150	ft
Treatment zone thickness	60	ft
Treatment zone volume	9,240,000	ft3
Soil dry bulk density	125	lb/ft3
Mass of soil in treatment zone	577,500	U.S. tons
Estimated total porosity	24%	
EHC mass calculations:		
Required EHC by soil mass in plume	0.07%	
Mass of EHC Required	808,500	lbs
PRB application rates:		
Volume pore space in PRBs	258,122	ft3
Percentage EHC by soil mass in PRBs	0.61%	
Slurry volume to pore space volume in PRB	15.3%	
EHC concentration in groundwater	3.1	lbs/ft3
Preparation of EHC Slurry:		
Percent solids in slurry (can be altered)	29%	
Volume water required	242,686	U.S. gallons
Slurry volume to inject	294,884	U.S. gallons
Injection details:		
Spacing between injection lines	150	ft
Number of injection lines required	5	lines
Spacing between injection points within lines	16	ft
Number of points per line	14	points/line
Total number of injection points	70	points
Mass EHC per point	11550	lbs
Volume water per point	3467	U.S. gallons
Slurry volume per point	4213	U.S. gallons
Mass EHC vertical distribution	193	lbs/ vertical ft
Optional Hole Blok for filling boreholes:		
Mass Hole Blok required, assuming 2" diameter bores	18,350	lbs

Using an estimated average linear groundwater velocity of 1 ft/day (360 ft/year) in the plume area, this provides a residence time of 16 days in a 16 ft wide EHC amended zone. The downgradient extent of the PRB will depend on the linear groundwater velocity; at a site in KS, we have observed significant benefits at a distance > 600 ft downgradient of the PRB within a 3 year period.

OPTIONAL USE OF INOCULANTS FOR RAPID DCE DEGRADATION

The accumulation of DCE on site indicates that the naturally occurring microbial population may be catabolically limited and that the remedial process might benefit from the addition of inoculants with known abilities to rapidly biodegrade DCE and related compounds. Although not typically required for ISCR as defined above, inoculants have been useful for these situations. Therefore once favorable redox conditions (ORP < -75 mV, DO <0.2 mg/L, pH between 6.5 and 7.5) have been attained following EHC addition, dehalococcoides (DHC) cultures can be added if DCE is still present at high concentrations.

The DHC inoculant will contain at least 1x10E10 cfu/ml of live bacteria including high numbers of dehalococcoides species with known abilities to biodegrade DCE. The target density of DHC cells in the treated aquifer area will be 2x10E6 cfu/ml. A total of 292 L of inoculum are required for the total PRB area.

OPTIONAL USE OF REACTIVE BOREHOLE SEALANT

It is very important to effectively seal the DPT bore holes, and HoleBlok+ provides an excellent, reactive sealant to enhance overall remedial performance which should be prescribed for the injection contractor. A total of 18,350 lbs of HoleBlok+ would be required for total PRB area.

DISTRIBUTION OF RESPONSIBILITIES

For field scale work at the Site, Adventus will provide environmental biotechnology and design support. It is our intention and understanding that Haley & Aldrich (Client) will be responsible for remedial construction, permitting, performance monitoring and reporting. The distribution of responsibilities envisioned is as follows:

1. Adventus will provide and arrange delivery of EHC to the Site.
2. Client will be responsible for remedial construction contracting.
3. It is highly recommended that Adventus personnel be on site during project start-up to support Client's field staff.
4. Adventus will provide data interpretation to Client upon request.
5. Adventus will provide technical writing support to Client, upon request.
6. Client will provide manpower for receiving shipments, monitoring treatment performance and collecting samples.
7. Client will maintain overall project responsibility, and will maintain all client contact and control of the Site.
8. Client will be responsible for all health and safety, permitting and approvals, sampling and analytical costs along with all data management and reporting costs.

COST ESTIMATE

AAI's material and delivery costs for the proposed applications are presented below (**Table 2**). These costs include EHC and estimated delivery to the Site. Adventus oversight, labor and travel are presented as highly recommended options. These costs do not include the remedial construction or services assigned to Client. This pricing is valid for 30 days.

Adventus will provide copies of our patents and written, full indemnification backed by insurance coverage to Client and the end-user / client from any lawsuits purporting patent infringement or other technology violations.

Adventus warrants the performance of its technology. In the event that the prescribed EHC injections do not yield at least 80% reduction in overall CVOC concentrations in groundwater within the treatment zone within 9 to 12 months, then we will provide an equivalent amount of EHC at 50% of the listed price (plus delivery costs). Adventus' field installation oversight would also be provided at no cost. This performance guarantee requires that a representative from Adventus is on site for the initiation of the project and that the injections are conducted according with Adventus' recommendations.

Table 2: ISCR mass requirements and cost (USD).

Item	PRB Areas
EHC Mass (lb)	808,500
EHC Unit Price [1]	$1.50
EHC Cost	$1,212,750
Shipping Estimate [3]	$50,000
OPTIONAL Adventus technical support, field oversight and travel (2 to 3 days on site) [4]	($5,000)
OPTIONAL inoculum (L)	(292)
OPTIONAL Inoculum Cost ($115/L excluding delivery)	($33,580)
OPTIONAL HolePlug+ (lbs)	(18,350)
OPTIONAL HolePlug+ cost ($37/50 lbs excluding delivery)	($13,579)
TOTAL COST [5]	**$1,262,750**

1) Price valid for 30 days. Volume discount applied where appropriate and assumes payment within 45 days. Any applicable taxes not included. Please provide a copy of your tax exempt certificate or resale tax number when placing your order.
3) Shipping billed at actual cost plus 8%. Transportation quotes assume 5 to 7 day delivery time via truck, no lift gate, no pallet jack.
4) Field oversight is presented as a recommended option and not included in the total cost. The Adventus performance warranty (below) is predicated on our oversight to verify material emplacement conditions. If additional field oversight is desired, it can be provided on a time and expense basis.
5) General terms and conditions for product sales can be found at www.adventusgroup.com/pdfs/pricing/Product_Sales_Terms_General_Conditions_APR10.pdf
6) Reactive Hole Blok (ZVI amended) is presented as a recommended option for filling injection boreholes, and is not included in the total cost. Borehole diameter of 2 inches assumed.

On behalf of Adventus Americas Inc., I thank you for your interest in our products and technologies. Please contact me by telephone at (303) 838-3823 or by email at joanna.moreno@adventusgroup.com if you have any questions regarding this proposal.

Yours truly,

Adventus Americas Inc.

Via e-mail

Joanna Moreno, PHG
Director of Groundwater Services

Cc: Jim Mueller – Adventus Americas

D6 – Alternative 6
ISCO + Hydraulic Barrier

TABLE D6a
Feasibility Screening Results
Phoenix-Goodyear Airport-North Superfund Site
Goodyear, Arizona

ESTIMATE OF PROBABLE COST
ISCO Permanganate + Hydraulic Barrier (Alternative 6)

NO.	ITEM	ESTIMATED QTY RANGE	UNIT (EA, LF, LS)	UNIT PRICE RANGE	ESTIMATED COST RANGE	COST SOURCE
1.00	**Permits, Design, and Work Plan**					
1.01	Health & Safety Plan	1 - 1	LS	$10,000 - $10,000	$10,000 - $10,000	Estimate from other sites
1.02	Underground Injection Control Permit	1 - 1	LS	$10,000 - $15,000	$10,000 - $15,000	Estimate from other sites
1.03	Pilot testing	1 - 1	LS	$50,000 - $75,000	$50,000 - $75,000	Estimate from other sites
1.04	Permits, design, office support	1 - 1	LS	$80,062 - $80,062	$80,062 - $80,062	Estimate from other sites
1.05	Work Plan and Report	1 - 1	LS	$69,233 - $69,233	$69,233 - $69,233	Estimate from other sites
		Permits, Design, and Work Plan Subtotal:			***$219,300 - $249,300***	
2.00	**Full Scale Mobilization/Demobilization**					
2.01	Injection Contractor Mob	352 - 352	LIFT	$2,000 - $2,000	$704,000 - $704,000	Quote in D-1
2.02	Drilling Contractor	1 - 1	LS	$1,500 - $3,000	$1,500 - $3,000	Quote in D-1
2.03	Fencing	5 - 5	LS	$2,300 - $2,300	$11,500 - $11,500	Quote in D-1
2.04	Aboveground piping installation from MTS	10,500 - 10,500	FT	$7 - $10	$73,500 - $105,000	Estimate from other sites
2.05	Secondary containment	25 - 30	MO	$500 - $1,000	$12,500 - $30,000	Quote in D-1
2.06	Tank rental and misc equipment	5 - 10	MO	$1,500 - $2,000	$7,500 - $20,000	Quote in D-1
		Full Scale Mobilization/Demobilization Subtotal:			***$810,500 - $873,500***	
3.00	**Injection and Monitoring Well Installation**					
3.01	Survey	1 - 2	DAY	$1,000 - $1,500	$1,000 - $3,000	Estimate from other sites
3.02	Driller installation of monitoring wells	12 - 12	WELL	$16,050 - $16,050	$192,600 - $192,600	Quote in D-1
3.03	Driller installation, development of permanent injection wells	45 - 45	WELL	$15,250 - $15,250	$686,250 - $686,250	Quote in D-1
3.04	YR 1 distribution coring	1 - 1	LS	$72,166 - $72,166	$72,166 - $72,166	Quote in D-1
3.05	Solid waste disposal	70 - 79	BIN	$500 - $750	$35,000 - $59,250	Quote in D-1
3.06	Connection to MTS for provision of treated water to source area	1 - 1	LS	$75,000 - $125,000	$75,000 - $125,000	Estimate from other sites
3.07	Analytical lab	70 - 70	SAMPLE	$120 - $120	$8,400 - $8,400	Quote in D-1
3.08	Oversight	1 - 1	LS	$84,418 - $84,418	$84,418 - $84,418	Estimate from other sites
3.09	Baseline sampling	82 - 82	WELL	$600 - $800	$49,200 - $65,600	Quote in D-1
		Injection and Monitoring Well Installation Subtotal:			***$1,204,000 - $1,296,700***	
4.00	**Year 1 Site Set-up and Injection Activities**					
4.01	Survey	1 - 2	DAY	$1,000 - $1,500	$1,000 - $3,000	Estimate from other sites
4.02	Site set-up (secondary containment, decon pad, H&S Equipment)	1 - 1	LS	$28,800 - $35,000	$28,800 - $35,000	Estimate from other sites
4.03	Injection oversight	1 - 1	LS	$219,632 - $219,632	$219,632 - $219,632	Estimate from other sites
4.04	Amendments (KMnO4)	72 - 72	LIFTS	$3,920 - $4,135	$282,236 - $297,700	Calculations and Quote in D-6
4.05	Injections	72 - 72	LIFTS	$3,400 - $3,400	$244,800 - $244,800	Estimate from other sites
4.06	Analytical suite (standard TAT)	48 - 48	SUITE	$621 - $621	$29,808 - $29,808	Quote in D-1
4.07	Data validation	1 - 1	LS	$5,000 $5,000	$5,000 - $5,000	Estimate from other sites
4.08	Reporting and meetings	1 - 1	LS	$62,168 - $62,168	$62,168 - $62,168	Estimate from other sites
		Year 1 Site Set-up and Injection Activities Subtotal:			***$873,400 - $897,100***	

TABLE D6a
Feasibility Screening Results
Phoenix-Goodyear Airport-North Superfund Site
Goodyear, Arizona

ESTIMATE OF PROBABLE COST
ISCO Permanganate + Hydraulic Barrier (Alternative 6)

NO.	ITEM	ESTIMATED QTY RANGE	UNIT (EA, LF, LS)	UNIT PRICE RANGE	ESTIMATED COST RANGE	COST SOURCE
5.00	**Year 2 Site Set-up and Injection Activities**					
5.01	Survey	1 - 2	DAY	$1,000 - $1,500	$1,000 - $3,000	Estimate from other sites
5.02	Site set-up (secondary containment, decon pad, H&S Equipment)	1 - 1	LS	$28,800 - $35,000	$28,800 - $35,000	Estimate from other sites
5.03	Injection oversight	1 - 1	LS	$219,632 - $219,632	$219,632 - $219,632	Estimate from other sites
5.04	Amendments (KMnO4)	114 - 114	LIFTS	$3,834 - $4,050	$437,046 - $461,700	Calculations and Quote in D-6
5.05	Injections	114 - 114	LIFTS	$3,400 - $3,400	$387,600 - $387,600	Estimate from other sites
5.06	Analytical suite (standard TAT)	48 - 48	SUITE	$621 - $621	$29,808 - $29,808	Quote in D-1
5.07	Data validation	1 - 1	LS	$5,000 $5,000	$5,000 - $5,000	Estimate from other sites
5.08	Reporting and meetings	1 - 1	LS	$62,168 - $62,168	$62,168 - $62,168	Estimate from other sites
				Year 2 Site Set-up and Injection Activities Subtotal:	***$1,171,100 - $1,203,900***	
6.00	**Year 3 Site Set-up and Injection Activities**					
6.01	Survey	1 - 2	DAY	$1,000 - $1,500	$1,000 - $3,000	Estimate from other sites
6.02	Site set-up (secondary containment, decon pad, H&S Equipment)	1 - 1	LS	$28,800 - $35,000	$28,800 - $35,000	Estimate from other sites
6.03	Injection oversight	1 - 1	LS	$219,632 - $219,632	$219,632 - $219,632	Estimate from other sites
6.04	Amendments (KMnO4)	36 - 36	LIFTS	$4,129 - $4,362	$148,644 - $157,028	Calculations and Quote in D-6
6.05	Injections	36 - 36	LIFTS	$3,400 - $3,400	$122,400 - $122,400	Estimate from other sites
6.06	Analytical suite (standard TAT)	48 - 48	SUITE	$621 - $621	$29,808 - $29,808	Quote in D-1
6.07	Data validation	1 - 1	LS	$5,000 $5,000	$5,000 - $5,000	Estimate from other sites
6.08	Reporting and meetings	1 - 1	LS	$62,168 - $62,168	$62,168 - $62,168	Estimate from other sites
				Year 3 Site Set-up and Injection Activities Subtotal:	***$617,500 - $634,000***	
7.00	**Year 4 Site Set-up and Injection Activities**					
7.01	Survey	1 - 2	DAY	$1,000 - $1,500	$1,000 - $3,000	Estimate from other sites
7.02	Site set-up (secondary containment, decon pad, H&S Equipment)	1 - 1	LS	$28,800 - $35,000	$28,800 - $35,000	Estimate from other sites
7.03	Injection oversight	1 - 1	LS	$219,632 - $219,632	$219,632 - $219,632	Estimate from other sites
7.04	Amendments (KMnO4)	27 - 27	LIFTS	$4,129 - $4,362	$111,483 - $117,771	Calculations and Quote in D-6
7.05	Injections	27 - 27	LIFTS	$3,400 - $3,400	$91,800 - $91,800	Estimate from other sites
7.06	Analytical suite (standard TAT)	48 - 48	SUITE	$621 - $621	$29,808 - $29,808	Quote in D-1
7.07	Data validation	1 - 1	LS	$5,000 $5,000	$5,000 - $5,000	Estimate from other sites
7.08	Reporting and meetings	1 - 1	LS	$62,168 - $62,168	$62,168 - $62,168	Estimate from other sites
				Year 4 Site Set-up and Injection Activities Subtotal:	***$549,700 - $564,200***	
8.00	**Year 5 Site Set-up and Injection Activities**					
8.01	Survey	1 - 2	DAY	$1,000 - $1,500	$1,000 - $3,000	Estimate from other sites
8.02	Site set-up (secondary containment, decon pad, H&S Equipment)	1 - 1	LS	$28,800 - $35,000	$28,800 - $35,000	Estimate from other sites
8.03	Injection oversight	1 - 1	LS	$219,632 - $219,632	$219,632 - $219,632	Estimate from other sites
8.04	Amendments (KMnO4)	36 - 36	LIFTS	$4,619 - $4,880	$166,283 - $175,663	Calculations and Quote in D-6

TABLE D6a
Feasibility Screening Results
Phoenix-Goodyear Airport-North Superfund Site
Goodyear, Arizona

ESTIMATE OF PROBABLE COST
ISCO Permanganate + Hydraulic Barrier (Alternative 6)

NO.	ITEM	ESTIMATED QTY RANGE	UNIT (EA, LF, LS)	UNIT PRICE RANGE	ESTIMATED COST RANGE	COST SOURCE
8.05	Injections	36 - 36	LIFTS	$3,400 - $3,400	$122,400 - $122,400	Estimate from other sites
8.06	Analytical suite (standard TAT)	18 - 18	SUITE	$621 - $621	$11,178 - $11,178	Quote in D-1
8.07	Data validation	1 - 1	LS	$5,000 $5,000	$5,000 - $5,000	Estimate from other sites
8.08	Reporting and meetings	1 - 1	LS	$62,168 - $62,168	$62,168 - $62,168	Estimate from other sites
		Year 5 Site Set-up and Injection Activities Subtotal:			***$616,500 - $634,000***	
	CONSTRUCTION AND MATERIALS COST SUBTOTAL (TASKS 1-8):				**$6,062,000 - $6,352,700**	
9.00	**Years 6-8 Performance Monitoring**					
9.01	Long-term monitoring and analytical costs	1 - 1	YR	$145,431 - $145,431	$145,431 - $145,431	Estimate from other sites
9.02	Reporting	1 - 1	YR	$132,268 - $132,268	$132,268 - $132,268	Estimate from other sites
		Years 6-8 Performance Monitoring Subtotal:			***$277,700 - $277,700***	
				NPV for O&M:	***$820,800 - $820,800***	
	O&M COST SUBTOTAL (TASK 9):				**$820,800 - $820,800**	
10.00	**Closure Costs**					
10.01	Abandon injection wells	45 - 45	WELL	$1,850 - $2,565	$83,250 - $115,425	Quote in D-1
10.02	Abandon groundwater wells	12 - 12	WELL	$1,760 - $2,475	$21,120 - $29,700	Quote in D-1
10.03	Solid waste disposal	29 - 57	BIN	$500 - $750	$14,500 - $42,750	Quote in D-1
10.04	Site restoration	1 - 1	LS	$25,000. - $50,000.	$25,000 - $50,000	Estimate from other sites
10.05	Oversight	1 - 1	LS	$120,000. - $120,000.	$120,000 - $120,000	Estimate from other sites
10.06	Reporting and meetings	1 - 1	LS	$60,000. - $100,000.	$60,000 - $100,000	Estimate from other sites
	CLOSURE COST SUBTOTAL (TASK 10):				**$323,870 - $457,875**	
		TOTAL COST (BARE):			**$7,206,670 - $7,631,375**	
		AVERAGE COST (BARE):			**$7,419,000**	
	TOTAL COST WITH -30% TO +50% CONTINGENCY:				**$5,193,300 - $11,128,500**	

TABLE D6b
Site Name: PGA North

Permanganate Estimation Spreadsheet

	Year 1	Units	Year 2	Units	Year 2	Units	Years 3 & 4	Units	Year 5	Units	TOTALS	Comments
Treatment Area Volume												
Length	**250**	ft	**62.5**	ft	**187.5**	ft	**400**	ft		ft		
Width	**150**	ft	**150**	ft	**150**	ft	**150**	ft		ft		
Area	37500	sq ft	9375	sq ft	28125	sq ft	60000	sq ft		sq ft		
Thickness	**35**	ft	**60**	ft	**50**	ft	**20**	ft		ft		
Total Volume	48611	cu yd	20833	cu yd	52083	cu yd	44444	cu yd		cu yd	165,972	TOTAL Treatment Volume (cu yd)
Soil Characteristics/Analysis												
Porosity	**7**	%	**7**	%	**7**	%	**7**	%		%		
Total Plume Pore Volume	687273	gal	294545	gal	736364	gal	628364	gal		gal	2,346,545	TOTAL Pore Volume (gal)
Avg Contaminant Conc	**1**	ppm	**1**	ppm	**1**	ppm	**1**	ppm		ppm		
Mass of Contaminant	5.73	lb	2.46	lb	6.14	lb	5.24	lb		lb		
PNOD (Permanganate Natural OD)	**6**	g/kg	**6**	g/kg	**6**	g/kg	**6**	g/kg		g/kg		Site-specific soil sample needed to confirm this value.
Effective PNOD	**15**	%	**15**	%	**15**	%	**15**	%		%		
Effective PNOD Calculated	0.9		0.9		0.9		0.9					
PNOD Oxidant Demand	129937.5	lb	55687.5	lb	139218.75	lb	118800	lb		lb		
Avg Stoichiometric Contam. Ox. Dem.	**2.4**	lb/lb	**2.4**	lb/lb	**2.4**	lb/lb	**2.4**	lb/lb		lb/lb		Primarily TCE
Contaminant Oxidant Demand	13.75	lb	5.89	lb	14.73	lb	12.57	lb		lb		
Theoretical Oxidant Demand	129951.25	lb	55693.39	lb	139233.48	lb	118812.57	lb		lb		
Confidence Factor	**1**		**1**		**1**		**1**					
Calculated Total Oxidant Demand	129,951	lb	55,693	lb	139,233	lb	118,813	lb	44,369	lb	488,060	TOTAL Permanganate Required (lb)
Injection Volumes												
Injection Concentration	**2.0%**		**2.0%**		**2.0%**		**2.0%**					
Volume of Injection Fluid	778,617	gal	333,693	gal	834,233	gal	711,879	gal	265,842	gal	2,658,422	TOTAL Injection Volume (gal)
Pore Volume Replaced											113.29	%
Injection Program												
# Lifts per Location	6		11		9		3					
# Injection Locations	12		3		9		21				45	TOTAL # Injection points
Total # Lifts	72		33		81		63		25		62	Average # Lifts
											249	TOTAL # lifts
Mass required (per lift)	1,805	lb	1,688	lb	1,719	lb	1,886	lb	1,782	lb	1774	Average mass required per lift
Volume of 2% solution (per lift)	10,814	gal	10,112	gal	10,299	gal	11,300	gal	10,676	gal	10631	Average gallons of 2% solution per lift
Estimated Costs												
Price (per lb)	$2.06		$2.06		$2.06		$2.06		$2.06			Range could be from $1.95 to $2.06 per pound based on quantity.
FOB	$30,000		$30,000		$30,000		$30,000		$30,000		$150,000	TOTAL FOB
TOTAL	$297,700		$144,800		$316,900		$274,800		$121,500		$1,155,700	TOTAL Cost

Carus Corporation
315 Fifth Street
P.O. Box 599
Peru, IL 61354 USA
Telephone: 800-435-6856

Price Quote

Date	07 Nov 2011	**Sales Representative**	KFRASCO
Quote #	1-KOCAY	**Customer Service Rep**	LMUELLER
Rev #	1	**Effective From**	07 Nov 2011
Status	In Progress	**Valid Through**	07 Dec 2011

To	Bill To	Ship To
CHRIS TSIATSIOS HALEY & ALDRICH **Phone** (714) 920-1593 **Fax**	HALEY & ALDRICH 3187 RED HILL AVENUE SUITE 155 COSTA MESA, CA 92626 USA	HALEY & ALDRICH 3187 RED HILL AVENUE SUITE 155 COSTA MESA, CA 92626 USA

Line	MinQty	Product	Description	U/M	Qty.	Recommend Price	Extended Price
1	0	2320-006-325	REMOX S 2000 LB	Pound	534,000	$ 2.06	$1,100,040.00

Note/Customer Purchase Order #: BUDGETARY QUOTATION

Payment Terms:		**Products**	**$1,100,040.00**
Shipping Method:	LANDSTAR	**Tax**	**$0.00**
Freight Terms:	FOB ORIGIN PREPAY/ADD	**Freight Charges ***	**$60,900.00**
Tax Exempt:	N		
Tax Rate(%):			
Requested Ship Date:	**Requested Delivery Date:**	**Total**	**$1,160,940.00**

Currency quoted as US Dollars.

Comments:

Standard freight is calculated to Phoenix, AZ (est. zip 85001) and includes a pallet jack and phone call prior to delivery.

* NOTE: Freight Charges are current as of this date and are subject to change based on actual ship date.

Rush orders (orders requiring shipment in less than two business days) may be subject to a surcharge.

This quotation is subject to our standard terms and conditions, and shall remain open for thirty (30) days unless otherwise stated above. If not accepted within thirty (30) days, Carus Corporation shall have no liability or obligation under this quotation. This quotation is made for the sole purpose of sourcing the prospective buyer's purchasing needs. As such, none of the information contained here in may be disclosed to any third party without Carus Corporation's written consent.

From:	Frasco, Kelly
To:	Tsiatsios, Chris
Subject:	RE: Permanganate Spreadsheet
Date:	Monday, November 07, 2011 7:07:37 AM
Attachments:	Haley & Aldrich Phoenix, AZ RemOx S Quote.pdf CFATS Review.pdf

---

Hello Chris,

I hope you had a nice weekend. Please find attached the quote for 534,000 pounds of RemOx® S ISCO reagent (potassium permanganate) in supersacks. Each supersack contains 2,000 pounds of RemOx S. Freight costs are included in the quote based on shipping the sacks to Phoenix, AZ. Please note that freight costs are current as of today and are may fluctuate based on current fuel prices. The RemOx S pricing in the quote is based on purchasing 534,000 pounds and would be valid through 2012.

Also attached is some information regarding storage regulation for potassium permanganate. Please let me know if you have any questions or need additional information.

Regards,
Kelly

Kelly Frasco
Director of Sales, Americas
Carus Remediation Technologies
315 Fifth Street
Peru, IL 61354
Tel 815.224.6654
Fax 815.224.6663
kelly.frasco@caruscorporation.com

From: Tsiatsios, Chris [mailto:CTsiatsios@haleyaldrich.com]
Sent: Friday, November 04, 2011 2:51 PM
To: Frasco, Kelly
Subject: RE: Permanganate Spreadsheet

Kelly,

The spreadsheet is attached with our Site specific data. Do you only supply costs for material or do you also have the capability to perform injections?

Thank you,

Chris Tsiatsios, P.E.
Engineer
Cell: 714.920.1593

HALEY & ALDRICH

From: Frasco, Kelly [mailto:Kelly.Frasco@caruscorporation.com]
Sent: Thursday, November 03, 2011 2:29 PM
To: Tsiatsios, Chris
Subject: Permanganate Spreadsheet

Hello Chris,

It was nice to speak with you today. Attached is the permanganate spreadsheet that I mentioned on the phone. It can be used to estimate the amount of permanganate needed for a remediation site. I will explain each of the input parameters (blue font in the spreadsheet) below.

- Treatment area – length, width and thickness in feet
- Porosity – default is 30%
- Average contaminant concentration in ppm
- PNOD is the permanganate natural oxidant demand. This value can be averaged for the different types of soil present at the site.
    - Strongly recommend collecting site soil and having it analyzed.
    - Estimated PNOD values by soil type
        1. Bedrock <1 g/kg
        2. Sand 1-5 g/kg
        3. Silt 4-8 g/kg
        4. Clay 7-12 g/kg
- Effective PNOD – The effective PNOD takes a portion of the actual PNOD value. It is a way to take the NOD value generated in the lab and convert it to the field. Typically for injections we use 10-20% of the PNOD value, but for in situ mixing we would use 50-60% of the PNOD value.
- Average stoichiometric demand - This is based on straight stoichiometry and the quantity of permanganate that is needed to oxidize one pound of the contaminant.
    - Enter 1.3 lb/lb for PCE, 2.4 for TCE, 4.4 for DCE and 8.5 for VC
- Confidence factor – The confidence factor is also a safety factor and is based on how well the site has been delineated. The value can range from a 1 (very confident) to a 3

(conservative). We really do not recommend using a 1 since that will not include any safety factor. If you feel more confident in the site data, I would recommend a 1.5 or 1.25. This value is a straight multiplier on the total amount of permanganate needed for a site.

Let me know when you are ready to discuss this.

Regards,
Kelly

Kelly Frasco
Director of Sales, Americas
Carus Remediation Technologies
315 Fifth Street
Peru, IL 61354
Tel 815.224.6654
Fax 815.224.6663
kelly.frasco@caruscorporation.com

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D7 – Alternative 7
In-Situ Thermal Heating (ERH) + Hydraulic Control

TABLE D7a
Feasibility Screening Results
Phoenix-Goodyear Airport-North Superfund Site
Goodyear, Arizona

ESTIMATE OF PROBABLE COST
ERH / Steam + Hydraulic Control (Alternative 7)

NO.	ITEM	ESTIMATED QTY RANGE	UNIT (EA, LF, LS)	UNIT PRICE RANGE	ESTIMATED COST RANGE	COST SOURCE
1.00	**Permits, Design, and Work Plan**					
1.01	Health & Safety Plan	1 - 1	LS	$5,000 - $10,000	$5,000 - $10,000	Estimate from other sites
1.02	Underground Injection Control Permit	1 - 1	LS	$100,000 - $200,000	$10,000 - $15,000	Estimate from other sites
1.03	Permits and Design	1 - 1	LS	$750,000 - $1,000,000	$750,000 - $1,000,000	Estimate from other sites
1.04	Work Plan and Report	1 - 1	LS	$100,000 - $200,000	$100,000 - $200,000	Estimate from other sites
				Permits, Design, and Work Plan Subtotal:	***$865,000 - $1,225,000***	
2.00	**Full Scale Mobilization/Demobilization**					
2.01	Procurement	1 - 1	LS	$225,000 - $450,000	$225,000 - $450,000	Estimate from other sites
2.02	Drilling Contractor	1 - 1	LS	$300,000 - $600,000	$300,000 - $600,000	Estimate from other sites
2.03	Temporary Facilities	1 - 1	LS	$200,000 - $400,000	$200,000 - $400,000	Estimate from other sites
2.04	Site Preparation (well abandonment, surface clearing)	1 - 1	LS	$152,000 - $317,000	$152,000 - $317,000	Calculations in D-7
2.05	Thermal Vendor Workplans	1 - 1	LS	$100,000 - $200,000	$100,000 - $200,000	Estimate from other sites
2.06	Reporting and meetings	1 - 1	MO	$30,000 - $50,000	$30,000 - $50,000	Estimate from other sites
				Full Scale Mobilization/Demobilization Subtotal:	***$1,007,000 - $2,017,000***	
3.00	**Injection and Monitoring Well Installation**					
3.01	Survey	1 - 1	DAY	$2,500 - $4,000	$2,500 - $4,000	Estimate from other sites
3.02	Driller installation of monitoring wells	12 - 12	WELL	$16,050 - $16,050	$192,600 - $192,600	Quote in D-1
3.03	Driller installation of electrodes, vapor recovery wells, TMPs, and PMPs	1 - 1	LS	$1,832,500 - $2,462,500	$1,832,500 - $2,462,500	Calculations in D-7
3.04	Driller installation of steam injection wells	1 - 1	LS	$485,100 - $849,600	$485,100 - $849,600	Calculations in D-7
3.05	Connection to MTS for provision of treated water to source area	1 - 1	LS	$75,000 - $125,000	$75,000 - $125,000	Estimate from other sites
3.06	Solid waste disposal	1 - 1	LS	$100,000 - $400,000	$100,000 - $400,000	Estimate from other sites
3.07	Analytical lab	1 - 1	LS	$15,000 - $30,000	$15,000 - $30,000	Estimate from other sites
3.08	Oversight	2 - 3	MO	$120,000 - $120,000	$240,000 - $360,000	Estimate from other sites
3.09	Baseline Sampling	1 - 1	LS	$5,000 - $6,000	$5,000 - $6,000	Estimate from other sites
				Injection and Monitoring Well Installation Subtotal:	***$2,947,700 - $4,429,700***	
4.00	**Thermal System Installation**					
4.01	Site Set-up (secondary containment, decon pad, H&S Equipment)	1 - 1	LS	$100,000 - $150,000	$100,000 - $150,000	Estimate from other sites
4.02	Oversight	2 - 2	MO	$120,000 - $120,000	$240,000 - $240,000	Estimate from other sites
4.03	Electrical Utility Connection	1 - 1	LS	$100,000 - $100,000	$100,000 - $100,000	Estimate from other sites
4.04	ERH System	1 - 1	LS	$200,000 - $400,000	$200,000 - $400,000	Estimate from other sites
4.05	Steam System	1 - 1	LS	$350,000 - $600,000	$350,000 - $600,000	Estimate from other sites
4.06	Liquid and Vapor System Install and refurbishment	1 - 1	LS	$950,000 - $1,850,000	$950,000 - $1,850,000	Calculations in D-7
4.07	Vapor Cover	1 - 1	LS	$250,000 - $550,000	$250,000 - $550,000	Estimate from other sites
4.08	Dewatering System	1 - 1	LS	$436,000 - $830,000	$436,000 - $830,000	Calculations in D-7
				Thermal System Installation Subtotal:	***$2,626,000 - $4,720,000***	

TABLE D7a
Feasibility Screening Results
Phoenix-Goodyear Airport-North Superfund Site
Goodyear, Arizona

ESTIMATE OF PROBABLE COST
ERH / Steam + Hydraulic Control (Alternative 7)

NO.	ITEM	ESTIMATED QTY RANGE	UNIT (EA, LF, LS)	UNIT PRICE RANGE	ESTIMATED COST RANGE	COST SOURCE
5.00	**System Startup and Phase Change Costs**					
5.01	Start up / Prove Out	1 - 1	LS	$150,000 - $250,000	$150,000 - $250,000	Estimate from other sites
5.02	System Move/Prove Out	1 - 1	EA	$150,000 - $250,000	$150,000 - $250,000	Estimate from other sites
5.03	Oversight	1 - 1	MO	$120,000 - $120,000	$120,000 - $120,000	Estimate from other sites
5.04	Reporting and meetings	1 - 1	LS	$30,000 - $30,000	$30,000 - $30,000	Estimate from other sites
				System Startup and Phase Change Costs Subtotal:	***$450,000 - $650,000***	
				CONSTRUCTION AND MATERIALS COST SUBTOTAL (TASKS 1-5):	**$7,895,700 - $13,041,700**	
6.00	**Operation and Maintenance (Phase I)**					
6.01	Electrical Energy Usage	6 - 10	MO	$624,096 - $907,776	$3,744,576 - $9,077,760	Calculations in D-7
6.02	Natural Gas Energy Usage	6 - 10	MO	$46,080 - $69,120	$276,480 - $691,200	Calculations in D-7
6.03	Caustic Usage	6 - 10	MO	$5,833 - $7,875	$34,998 - $78,750	Calculations in D-7
6.04	Other Consumables, electricity for pumps/SVE, carbon, utilities, etc.	1 - 1	LS	$200,000 - $275,000	$200,000 - $275,000	Calculations in D-7
6.05	ERH Operation and oversight	6 - 10	MO	$100,000 - $100,000	$600,000 - $1,000,000	Calculations in D-7
6.06	Treatment system OM&M	6 - 10	MO	$50,000 - $50,000	$300,000 - $500,000	Calculations in D-7
6.07	Dewatering Treatment system OM&M	6 - 10	MO	$25,000 - $25,000	$150,000 - $250,000	Calculations in D-7
6.08	Waste Disposal	6 - 10	MO	$42,000 - $42,000	$252,000 - $420,000	Estimate from other sites
6.09	Discharge Fees	6 - 10	MO	$16,667 - $30,000	$100,000 - $300,000	Estimate from other sites
6.10	Oversight	6 - 10	MO	$120,000 - $120,000	$720,000 - $1,200,000	Estimate from other sites
6.11	Repairs	6 - 10	MO	$45,000 - $45,000	$270,000 - $450,000	Estimate from other sites
6.12	Monitoring and Sampling	6 - 10	MO	$50,000 - $50,000	$300,000 - $500,000	Estimate from other sites
6.13	Reporting and meetings	6 - 10	MO	$30,000 - $40,000	$180,000 - $400,000	Estimate from other sites
				Operation and Maintenance (Phase I) Subtotal:	***$7,128,054 - $15,142,700***	
7.00	**Closure Costs**					
7.01	Abandon ERH probes	1 - 1	LS	$411,000 - $608,000	$411,000 - $608,000	Calculations in D-7
7.01	Abandon Injection Wells	1 - 1	LS	$343,000 - $531,000	$343,000 - $531,000	Calculations in D-7
7.01	Closure borings	1 - 1	LS	$120,000 - $200,000	$120,000 - $200,000	Calculations in D-7
7.01	Demob ERH system	1 - 1	LS	$275,000 - $450,000	$275,000 - $450,000	Estimate from other sites
7.01	Demob Steam system	1 - 1	LS	$250,000 - $450,000	$250,000 - $450,000	Estimate from other sites
7.01	Decommission treatment systems	1 - 1	LS	$550,000 - $900,000	$550,000 - $900,000	Estimate from other sites
7.01	Site Restoration	1 - 1	LS	$500,000 - $1,000,000	$500,000 - $1,000,000	Estimate from other sites
7.01	Oversight	1 - 2	MO	$120,000 - $120,000	$120,000 - $240,000	Estimate from other sites
7.01	Reporting and meetings	2 - 3	MO	$37,500 - $50,000	$75,000 - $150,000	Estimate from other sites
				Closure Costs Subtotal:	***$2,644,000 - $4,529,000***	

TABLE D7a
Feasibility Screening Results
Phoenix-Goodyear Airport-North Superfund Site
Goodyear, Arizona

ESTIMATE OF PROBABLE COST
ERH / Steam + Hydraulic Control (Alternative 7)

NO.	ITEM	ESTIMATED QTY RANGE	UNIT (EA, LF, LS)	UNIT PRICE RANGE	ESTIMATED COST RANGE	COST SOURCE
8.00	**Other Costs**					
8.01	Thermal Vendor Fees	1 - 1	LS	$619,995 - $1,168,385	$619,995 - $1,168,385	Estimate from other sites
				Other Costs Subtotal:	***$619,995 - $1,168,385***	
	O&M COST SUBTOTAL (TASKS 6-8):				**$10,392,049 - $20,840,085**	
		TOTAL COST (BARE):			**$18,287,749 - $33,881,785**	
		AVERAGE COST (BARE):			**$26,084,800**	
	TOTAL COST WITH -30% TO +50% CONTINGENCY:				**$12,801,400 - $50,822,700**	

TABLE D7b

Haley & Aldrich Estimate of Costs for a Thermal Application

ASSUMPTIONS

52,500 sq ft. Heated interval 80 to 180 ft.
Total yards: 194,500 cubic yards
Assumes 137 electrodes on 18.5 ft centers. 20 temperature/pressure monitoring points. 66 vapor extraction wells.
Assumes 49 steam injection points on 35 ft centers.
Assumes 1 phase
Assume months of operation = 6 Months of operation (High Case) 10
All costs are in 2011 dollars.
Typical cost of 120 - 200 kWhr/cy

CAPITAL COSTS

	MLE	High	
Well Abandon - SVE Lines	$ 75,000	$ 200,000	Abandon SVE lines. Reasonable estimate
Well Abandon - GW Mon Wells	$ 77,000	$ 117,000	Abandon 11 Wells at $7k/well. High case is 13 wells at $9k per well.
Procurement	$ 225,000	$ 450,000	Reasonable estimate based on other sites
Install co-located electrodes and vapor recovery wells	$ 1,832,500	$ 2,462,500	137 wells x 130 feet x $65/LF, $55/LF for TMP and PMP (20 wells to 180 ft), and $85/LF for 66 Vapor wells to 85 ft. High assumes 35 additional wells (15 wells + 20 vapor recovery) to 180 feet and all at $100/LF. Based on similar size project.
Install steam injection wells	$ 485,100	$ 849,600	49 wells x 180 feet x $55/LF. High assumes 10 additional wells to 180 feet all at $80/LF. Based on similar size project.
Install monitoring wells	$ 60,000	$ 128,000	5 wells at $12k/well. High assumes 8 wells at $16k/well.
ERH system	$ 200,000	$ 400,000	Based on costs at other sites.
Steam system	$ 350,000	$ 600,000	Based on costs at other sites.
Treatment Systems for Liquid and Vapor	$ 950,000	$ 1,850,000	O/W separator, air stripper, GAC polisher, use existing SVE treatment system
Dewatering System	$ 436,000	$ 830,000	3 wells at $12k/well and $400K for a temporary GW treatment system. High assumes 5 wells at $16k/well and install own treatment system at $750K.
Electrical Utility Connection	$ 100,000	$ 100,000	Reasonable estimate based on other sites
Temporary Facilities	$ 200,000	$ 400,000	Reasonable estimate based on other sites
Vapor Cover	$ 250,000	$ 550,000	Reasonable estimate based on other sites
Subtotal: Direct Capital Costs	**$ 5,240,600**	**$ 8,937,100**	
INDIRECT CAPITAL COSTS			
Thermal Vendor Workplans	$ 100,000	$ 200,000	Reasonable estimate from other quotes
Engineering design, PM/technical review and construction oversight (at 20% of dir	$ 1,048,120	$ 1,787,420	
Startup / ProveOut	$ 150,000	$ 250,000	
CONTINGENCY (15%)	$ 980,808	$ 1,676,178	
Subtotal: Indirect Capital Costs	**$ 2,278,928**	**$ 3,913,598**	
TOTAL CAPITAL COSTS (DIRECT AND INDIRECT) =	**$ 7,519,528**	**$ 12,850,698**	$ 10,185,113 construction

OPERATION, MONITORING, AND MAINTENANCE (OM&M COSTS)					
Operations:					
Electrical Energy Usage	$ 3,744,576	$ 9,077,760	7880 KW system x 6 months x $0.11/kWhr. High assumes 10 months & $0.16/KWhr. Assumed 175 kWhr/cy.		
Natural Gas Energy Usage	$ 276,480	$ 691,200	3,000 SCFM TO at 6,400,000 BTUH at $10/MBTU. High case assumes $15/MBTU		
Caustic Usage	$ 35,000	$ 78,750	175,000 lbs of 50% solution at $0.20 per pound. HC assumes 50% increase in caustic and cost		
Other Consumables, electricity for pumps/SVE, carbon, utilities, etc.	$ 200,000	$ 275,000	Lump (minor cost compared to ERH electrical)		
ERH Operation and oversight	$ 600,000	$ 1,000,000	$100k per month. 6 month for MLE and 10 month for HC		
Treatment system OM&M	$ 300,000	$ 500,000	Operation of GAC / TO System. Estimated ROM at $300k for MLE. Higher for HC. Based on costs at other sites.		
Dewatering Treatment system OM&M	$ 150,000	$ 250,000	Operation of GAC / TO System. Estimated ROM at $150k for MLE. Higher for HC.		
Waste Disposal	$ 200,000	$ 350,000	ROM estimate		
Prove Out	$ 150,000	$ 250,000	ROM estimate		
Discharge Fees	$ 100,000	$ 300,000	ROM estimate		
Maintenance:					
Repairs	$ 200,000	$ 450,000	ROM estimate		
Monitoring					
Monitoring well sampling, reporting, system sampling	$ 200,000	$ 450,000	ROM estimate		
Subtotal: OM&M Costs	**$ 6,156,056**	**$ 13,672,710**			
CLOSURE COSTS (all phases)					
Abandon ERH probes	$ 411,000	$ 608,000	137 probes x $3k per probe. High assumes 152 probes x $4K per probe.		
Abandon Injection Wells	$ 343,000	$ 531,000	49 wells x $7k per well. High assumes 59 wells x $9k per well.		
Closure borings	$ 120,000	$ 200,000	15 borings x $8k per boring (25 borings High Case)		
Demob ERH system	$ 275,000	$ 450,000	Based on costs at other sites		
Demob Steam system	$ 250,000	$ 450,000	Based on costs at other sites		
Decommission treatment systems	$ 550,000	$ 900,000	About twice as much labor as ERH decommission		
Site Restoration	$ 500,000	$ 1,000,000	Reasonable estimate. Assumes vapor cover must be removed		
Closure Report	$ 75,000	$ 150,000	Reasonable estimate		
Subtotal: Closure Costs	**$ 2,524,000**	**$ 4,289,000**			
TOTAL COSTS (CAPITAL + OM&M + CLOSURE)	**$ 16,199,584**	**$ 30,812,408**			
FEES FOR USAGE (3.5%)	**$ 566,985**	**$ 1,078,434**	Total	-30%	50%
GRAND TOTAL	**$ 16,766,569**	**$ 31,890,842**	$ 24,328,706	$ 11,736,598.61	$ 47,836,263.42
			$ 14,143,593	omm	
	$ 86	$ 164	Assumed 194,500 CY		

APPENDIX E

Sustainability Inputs and Assumptions

APPENDIX E
SUSTAINABILITY INPUTS AND ASSUMPTIONS

The relative sustainability performance of each remediation alternative was addressed within the Protection of Human Health and the Environment criterion. The following sustainability indicators were considered in the sustainability evaluation:

- Air emissions, including:
  - Greenhouse gas (GHG) emissions; and
  - Nitrogen oxides (NO_x), sulfur oxides (SO_x), particulate matter (PM), and hazardous air pollutant (HAP) emissions.
- Water, including:
  - Potable water consumption; and
  - Groundwater extraction.
- Materials and waste, including:
  - Raw material consumption;
  - Non-hazardous solid waste production; and
  - Wastewater production.

Quantitative evaluations were performed where feasible and data were readily available. Quantitative evaluations were performed for each of the sustainability indicators. The evaluations were conducted based on the methodology described the United States Environmental Protection Agency, Methodology for Understanding and Reducing a Project's Environmental Footprint EPA 542-R-12-002 (2012).

AIR EMISSIONS

The assumptions made for the air emissions evaluations are summarized in Table E-1. The air emissions generated during the implementation of each alternative, including GHG, NO_x, SO_x, PM, and HAP emissions, are summarized in Table E-2. NOx, SOx, PM, and HAP emissions are measured in pounds and GHG emissions are measured in tons. Alternative 7 (electrical resistive heating with steam injection [ERH/Steam] and hydraulic control) would generate the most GHG emissions. Excluding Alternative 1 (no action), Alternative 6 (in-situ chemical oxidation [ISCO]) would produce the least GHG emissions.

WATER

Estimated potable water required for decontamination activities during the implementation of the remedial alternatives is provided in Table E-3. Excluding Alternative 1 (No Action), all alternatives are estimated to require the same amount of potable water. Table E-3 also includes estimated volumes of injected water from the treatment system back into the aquifer. Alternative 7 (ERH/Steam and hydraulic control) would consume the greatest amount of potable water, with Alternative 2 (in-well air stripping [IWAS] and hydraulic barrier) requiring the least amount of potable water. However, Alternative 7 would also inject the most water back into the aquifer as part of the remedy.

Extraction of impacted groundwater would be required for each remedial alternative. The total volume of extracted groundwater, expressed in gallons, was estimated for the different remedial alternatives. The estimated quantities of impacted groundwater extracted as part of the different remedial alternatives are provided in Table E-4. Apart from Alternative 1 (no action), all alternatives are estimated to extract approximately the same volume of impacted groundwater.

MATERIALS AND WASTE

Several raw materials would be required during the implementation of the remedial alternatives. The estimated total quantities of the different raw materials, expressed in tons, were summed to evaluate the total quantity of raw materials required for the duration of each remedial alternative. The estimated total quantities of raw materials are presented in Table E-5. Alternative 4 (nano-scale zero valent iron [nZVI], ZVI, anaerobic reductive dechlorination [ARD], and hydraulic barrier) would require the greatest amount of raw materials. Alternative 1 (no action), Alternative 2 (IWAS and hydraulic barrier) would consume the least amount of raw materials.

The quantities of non-hazardous solid waste and wastewater generated during the implementation of the different remedial alternatives were summed to evaluate the total quantities of solid and liquid waste for the duration of each alternative. Non-hazardous solid waste, expressed in tons, and wastewater, measured in gallons, produced during the duration of each alternative are provided in Tables E-6 and E-7, respectively. Alternative 1 (no action) would not generate any solid or liquid waste. Alternatives 2 through 7 would generate non- hazardous soil waste during construction. Alternative 7 (ERH/Steam and hydraulic control) would also produce non-hazardous polyvinyl chloride waste. Alternative 5 (ZVI, ARD, and hydraulic barrier) would produce the greatest quantity of solid waste, with Alternative 2 (IWAS and hydraulic barrier) producing the least amount of solid waste. Alternative 5 (ZVI, ARD, and hydraulic barrier) would also generate the most liquid waste, producing over three times more wastewater than the alternative producing the least amount of liquid waste, Alternative 7 (ERH/Steam and hydraulic control).

SUMMARY

The overall results for each of the sustainability indicators considered in this analysis are presented in Table E-8.

TABLE E-1
CARBON FOOTPRINT ASSUMPTIONS
PHOENIX-GOODYEAR AIRPORT-NORTH SUPERFUND SITE

Remedial Alternative	Type of Emission	Activity	Input Details	Assumptions
Alternative 1 - No Action	Assume no remediation activities take place.			
Alternative 2 - In-well air stripping (IWAS) and hydraulic barrier	On-Site Mobile Combustion	Operation of on-Site equipment	Forklift (Hp 100-175)	Forklift operates for 8 hours per day, 15 days per month for 5 months and travels 40 miles roundtrip to the site.
			Drill Rig (Hp 750-1000)	Drill rig operates for 12 hours per day, 15 days per month for 5 months and travels 40 miles roundtrip 5 times to the site.
			Other Construction Equipment (Hp 100-175)	Other construction equipment operates for 8 hours per day, 15 days per month for 5 months.
			Cement/Mortar Mixer (Hp 100-175)	Cement/mortar mixer operates 8 hours per day, 20 days per month for 2 months and travels 40 miles roundtrip 7 times to the site.
	Off-Site Mobile Combustion	Transportation of workers	Environmental Engineer	1 environmental engineer travels 740 miles roundtrip to the Site by airplane twice.
			Engineering Manager	1 engineering manager works 10 days a month for 5 months and travels 35 miles roundtrip to the Site each day by passenger vehicle (gasoline).
			Environmental Scientists	2 environmental scientists work 15 days a month for 5 months and travel 35 miles roundtrip to the Site each day by passenger vehicle (gasoline).
			Earth Drillers	3 earth drillers work 15 days a month for 5 months and travel 35 miles roundtrip to the Site by heavy-duty truck (diesel).
			Construction Managers	2 construction managers work 20 days a month for 2 months and travel 35 miles roundtrip to the Site each day by passenger vehicle (gasoline).
			Environmental Scientists	2 environmental scientists perform well maintenance/sampling for 4 events per project period, 10 days each event, 8 hours per day and travels 40 miles roundtrip by light-duty truck (gasoline).
		Transportation of raw materials	Transportation of Cement	10 loads transported 35 miles roundtrip by heavy-duty truck (diesel).
			Transportation of PVC	10 loads transported 35 miles roundtrip by heavy-duty truck (diesel).
			Transportation of Gravel, Betonite, Steel Screening	10 loads transported 35 miles roundtrip by heavy-duty truck (diesel).
		Transportation of waste	Transportation of Soil	17 loads transported 64 miles roundtrip by heavy-duty truck (diesel).
	On-Site Indirect Emissions	On-Site electricity use	Air Sparging Equipment	17 pieces of air sparging equipment requiring 1 kilowatt (kW), 12 hours per day, 25 days per month for 48 months.
			Dual-Phase Extraction Pump	17 dual-phase extraction pumps requiring 1.5 kW, 12 hours per day, 25 days per month for 48 months.
			Generator	2 generators requiring 20 kW, 8 hours per day, 20 days per month for 5 months.
	Raw Material Manufacturing	Raw material requirements for Site activities	Cement	77 cubic yards of cement are required.
			Gravel	121,500 pounds of gravel are required.
			Steel	1,040 pounds of steel are required.
			PVC	48,034 pounds of PVC are required.
			Bentonite Pellets	1 cubic yard of bentonite pellets is required.
Alternative 3 - Anaerobic reductive dechlorination (ARD) and hydraulic barrier	On-Site Mobile Combustion	Operation of on-Site equipment	Forklift (Hp 100-175)	Forklift operates for 8 hours per day, 15 days per month for 5 months and travels 40 miles roundtrip to the site.
			Drill Rig (Hp 750-1000)	Drill rig operates for 12 hours per day, 15 days per month for 5 months and travels 40 miles roundtrip 5 times to the site.
			Cement/Mortar Mixer (Hp 100-175)	Cement/mortar mixer operates 8 hours per day, 15 days per month for 5 months and travels 40 miles roundtrip 4 times to the site.
			Cement/Mortar Mixer (Hp 100-175)	Cement/mortar mixer operates 8 hours per day, 15 days per month for 2 months and travels 40 miles roundtrip 3 times to the site.
	Off-Site Mobile Combustion	Transportation of workers	Environmental Engineer	1 environmental engineer travels 740 miles roundtrip to the Site by airplane twice.
			Engineering Managers	1 engineering manager works 10 days a month for 5 months and travels 35 miles roundtrip to the Site each day by passenger vehicle (gasoline).
			Environmental Scientists	2 environmental scientists work 15 days a month for 5 months and travel 35 miles roundtrip to the Site each day by passenger vehicle (gasoline).
			Earth Drillers	3 earth drillers work 15 days a month for 5 months and travel 35 miles roundtrip to the Site by heavy-duty truck (diesel).
			Environmental Scientists	2 environmental scientists perform well maintenance/sampling for 3 years, 5 events per year, 8 hours per day and travel 40 miles roundtrip by light-duty truck (gasoline).

TABLE E-1
CARBON FOOTPRINT ASSUMPTIONS
PHOENIX-GOODYEAR AIRPORT-NORTH SUPERFUND SITE

Remedial Alternative	Type of Emission	Activity	Input Details	Assumptions
Alternative 3 (cont.)	Off-Site Mobile Combustion	Transportation of raw materials	Transportation of Bioaugmentation	5 loads transported 4,560 miles roundtrip by heavy-duty truck (diesel).
			Transportation of Emulsified Oil	6 loads transported 3,500 miles roundtrip by heavy-duty truck (diesel).
			Transportation of Cement	5 loads transported 35 miles roundtrip by heavy-duty truck (diesel).
			Transportation of PVC	5 loads transported 35 miles roundtrip by heavy-duty truck (diesel).
			Transportation of Gravel, Bentonite, Steel Screening	5 loads transported 35 miles roundtrip by heavy-duty truck (diesel).
		Transportation of waste	Transportation of Soil	13 loads transported 64 miles roundtrip by heavy-duty truck (diesel).
	On-Site Indirect Emissions	On-Site electricity use	Generator	2 generators requiring 20 kW, 8 hours per day, 20 days per month for 5 months.
			Recirculation Pump	2 recirculation pumps requiring 10 kW, 4 hours per day, 10 days per month for 5 months.
	Raw Material Manufacturing	Raw material requirements for Site activities	Cement	123 cubic yards of cement are required.
			Gravel	35,100 pounds of gravel are required.
			Steel	720 pounds of steel are required.
			PVC	24,521 pounds of PVC are required.
			Bentonite	106 cubic yards of bentonite are required.
			Bioaugmentation	1,280 liters of bioaugmentation are required.
			Emulsified Oil	214,830 pounds of emulsified oil are required.
Alternative 4 - Nano-scale zero valent iron (nZVI), ZVI, ARD, and hydraulic barrier	On-Site Mobile Combustion	Operation of on-Site equipment	Forklift (Hp 100-175)	Forklift operates for 8 hours per day, 15 days per month for 5 months and travels 40 miles roundtrip to the site.
			Drill Rig (Hp 750-1000)	Drill rig operates for 12 hours per day, 15 days per month for 5 months and travels 40 miles roundtrip 5 times to the site.
			Cement/Mortar Mixer (Hp 100-175)	Cement/mortar mixer operates 8 hours per day, 15 days per month for 5 months and travels 40 miles roundtrip 5 times to the site.
	Off-Site Mobile Combustion	Transportation of workers	Environmental Engineer	1 environmental engineer travels 740 miles roundtrip to the Site by airplane twice.
			Engineering Managers	1 engineering manager works 10 days a month for 5 months and travels 35 miles roundtrip to the Site each day by passenger vehicle (gasoline).
			Environmental Scientists	2 environmental scientists work 15 days a month for 5 months and travel 35 miles roundtrip to the Site each day by passenger vehicle (gasoline).
			Earth Drillers	3 earth drillers work 15 days a month for 5 months and travel 35 miles roundtrip to the Site by heavy-duty truck (diesel).
			Environmental Scientists	2 environmental scientists perform well maintenance/sampling for 3 years, 5 events per year, 8 hours per day and travel 40 miles roundtrip by light-duty truck (gasoline).
		Transportation of raw materials	Transportation of Zero-valent Iron	5 loads transported 4,100 miles roundtrip by heavy-duty truck (diesel).
			Transportation of Gravel, Bentonite, Steel Screening	5 loads transported 35 miles roundtrip by heavy-duty truck (diesel).
			Transportation of Cement	5 loads transported 35 miles roundtrip by light-duty truck (diesel).
			Transportation of PVC	5 loads transported 35 miles roundtrip by light-duty truck (diesel).
			Transportation of Emulsified Oil	5 loads transported 3,500 miles roundtrip by heavy-duty truck (diesel).
			Transportation of Bioaugmentation	5 loads transported 4,560 miles roundtrip by heavy-duty truck (diesel).
			Transportation of Liquid Nitrogen	5 loads transported 35 miles roundtrip by light-duty truck (diesel).
			Transportation of nZVI	5 loads transported 5,100 miles roundtrip by heavy-duty truck (diesel).
		Transportation of waste	Transportation of Soil	12 loads transported 64 miles roundtrip by heavy-duty truck (diesel).
	On-Site Indirect Emissions	On-Site electricity use	Recirculation Pump	2 recirculation pumps requiring 10 kW, 4 hours per day, 10 days per month for 5 months.
			10,000 psi Pump for Water Jets	1 pump for water jets requiring 15 kW, 4 hours per day, 10 days per month for 5 months.
			Generator	2 generators requiring 20 kW, 8 hours per day, 20 days per month for 5 months.
			Injection Pump	1 injection pump requiring 10 kW, 4 hours per day, 10 days per month for 5 months.
	Raw Material Manufacturing	Raw material requirements for Site activities	Cement	110 cubic yards of cement are required.
			Gravel	16 cubic yards of gravel are required.
			Steel	880 pounds of steel are required.
			PVC	22,667 pounds of PVC are required.
			Bentonite	89 cubic yards of bentonite are required.
			Zero-valent Iron	1,604,016 pounds of zero-valent iron are required.

TABLE E-1
CARBON FOOTPRINT ASSUMPTIONS
PHOENIX-GOODYEAR AIRPORT-NORTH SUPERFUND SITE

Remedial Alternative	Type of Emission	Activity	Input Details	Assumptions
Alternative 4 (cont.)	Raw Material Manufacturing	Raw material requirements for Site activities	Bioaugmentation	1,080 liters of bioaugmentation are required.
			Liquid Nitrogen	1,275 liters of liquid nitrogen are required.
			Emulsified Oil	120,120 pounds of emulsified oil are required.
			nZVI	133,560 pounds of nZVI required
Alternative 5 - ZVI, ARD, and hydraulic barrier	On-Site Mobile Combustion	Operation of on-Site equipment	Forklift (Hp 100-175)	Forklift operates for 8 hours per day, 15 days per month for 5 months and travels 40 miles roundtrip to the site.
			Drill Rig (Hp 750-1000)	Drill rig operates for 12 hours per day, 15 days per month for 5 months and travels 40 miles roundtrip 5 times to the site.
			Cement/Mortar Mixer (Hp 100-175)	Cement/mortar mixer operates 8 hours per day, 15 days per month for 5 months and travels 40 miles roundtrip times to the site.
	Off-Site Mobile Combustion	Transportation of workers	Environmental Engineer	1 environmental engineer travels 740 miles roundtrip to the Site by airplane twice.
			Engineering Managers	1 engineering manager works 10 days a month for 5 months and travels 35 miles roundtrip to the Site each day by passenger vehicle (gasoline).
			Environmental Scientists	2 environmental scientists work 15 days a month for 5 months and travel 35 miles roundtrip to the Site each day by passenger vehicle (gasoline).
			Earth Drillers	3 earth drillers work 15 days a month for 5 months and travel 35 miles roundtrip to the Site by heavy-duty truck (diesel).
			Environmental Scientists	2 environmental scientists perform well maintenance/sampling for 6 years, 5 events per year, 8 hours per day and travel 40 miles roundtrip by light-duty truck (gasoline).
	Off-Site Mobile Combustion (cont.)	Transportation of raw materials	Transportation of Zero-valent Iron	5 loads transported 3,520 miles roundtrip by heavy-duty truck (diesel).
			Transportation of Gravel, Bentonite, Steel Screening	5 loads transported 35 miles roundtrip by heavy-duty truck (diesel).
			Transportation of Cement	5 loads transported 35 miles roundtrip by light-duty truck (diesel).
			Transportation of PVC	5 loads transported 35 miles roundtrip by light-duty truck (diesel).
			Transportation of Bioaugmentation	5 loads transported 4,560 miles roundtrip by heavy-duty truck (diesel).
			Transportation of Liquid Nitrogen	5 loads transported 35 miles roundtrip by light-duty truck (diesel).
		Transportation of waste	Transportation of Soil	15 loads transported 64 miles roundtrip by heavy-duty truck (diesel).
	On-Site Indirect Emissions	On-Site electricity use	Recirculation Pump	2 recirculation pumps requiring 10 kW, 4 hours per day, 10 days per month for 5 months.
			10,000 psi Pump for Water Jets	1 pump for water jets requiring 15 kW, 4 hours per day, 10 days per month for 5 months.
			Generator	2 generators requiring 20 kW, 8 hours per day, 20 days per month for 5 months.
			Injection Pump	1 injection pump requiring 10 kW, 4 hours per day, 10 days per month for 5 months.
	Raw Material Manufacturing	Raw material requirements for Site activities	Cement	146 cubic yards of cement are required.
			Gravel	13 cubic yards of gravel are required.
			Steel	720 pounds of steel are required.
			PVC	28,741 pounds of PVC are required.
			Bentonite	129 cubic yards of bentonite are required.
			Zero-valent Iron	808,500 pounds of zero-valent iron are required.
			Bioaugmentation	1,080 liters of bioaugmentation are required.
			Liquid Nitrogen	1,275 liters of liquid nitrogen are required.
Alternative 6 - In-situ chemical oxidation (ISCO) using permanganate and hydraulic barrier	On-Site Mobile Combustion	Operation of on-Site equipment	Forklift (Hp 100-175)	Forklift operates for 8 hours per day, 15 days per month for 5 months and travels 40 miles roundtrip to the site.
			Drill Rig (Hp 750-1000)	Drill rig operates for 12 hours per day, 15 days per month for 5 months and travels 40 miles roundtrip 5 times to the site.
			Cement/Mortar Mixer (Hp 100-175)	Cement/mortar mixer operates 8 hours per day, 15 days per month for 5 months and travels 40 miles roundtrip 5 times to the site.
	Off-Site Mobile Combustion	Transportation of workers	Environmental Engineer	1 environmental engineer travels 740 miles roundtrip to the Site by airplane twice.
			Engineering Managers	1 engineering manager works 10 days a month for 5 months and travels 35 miles roundtrip to the Site each day by passenger vehicle (gasoline).
			Environmental Scientists	2 environmental scientists work 15 days a month for 5 months and travel 35 miles roundtrip to the Site each day by passenger vehicle (gasoline).
			Earth Drillers	3 earth drillers work 15 days a month for 5 months and travel 35 miles roundtrip to the Site by heavy-duty truck (diesel).
			Environmental Scientists	2 environmental scientists perform well maintenance/sampling for 3 years, 5 events per year, 8 hours per day and travel 40 miles roundtrip by light-duty truck (gasoline).

TABLE E-1
CARBON FOOTPRINT ASSUMPTIONS
PHOENIX-GOODYEAR AIRPORT-NORTH SUPERFUND SITE

Remedial Alternative	Type of Emission	Activity	Input Details	Assumptions
Alternative 6 (cont.)	Off-Site Mobile Combustion	Transportation of raw materials	Transportation of Permanganate	5 loads transported 3,500 miles roundtrip by heavy-duty truck (diesel).
			Transportation of Gravel, Bentonite, Steel Screening	5 loads transported 35 miles roundtrip by heavy-duty truck (diesel).
			Transportation of Cement	5 loads transported 35 miles roundtrip by light-duty truck (diesel).
			Transportation of PVC	5 loads transported 35 miles roundtrip by light-duty truck (diesel).
		Transportation of waste	Transportation of Soil	13 loads transported 64 miles roundtrip by heavy-duty truck (diesel).
	On-Site Indirect Emissions	On-Site electricity use	Recirculation Pump	2 recirculation pumps requiring 10 kW, 4 hours per day, 10 days per month for 5 months.
			Generator	2 generators requiring 20 kW, 8 hours per day, 20 days per month for 5 months.
			Injection Pump	1 injection pump requiring 10 kW, 4 hours per day, 10 days per month for 5 months.
	Raw Material Manufacturing	Raw material requirements for Site activities	Cement	124 cubic yards of cement are required.
			Gravel	21 cubic yards of gravel are required.
			Steel	1,200 pounds of steel are required.
			PVC	22,712 pounds of PVC are required.
			Bentonite	96 cubic yards of bentonite are required.
			Permanganate	289,606 pounds of permanganate are required.
Alternative 7 - Electrical resistive heating with steam injection (ERH/Steam) and hydraulic control	On-Site Stationary Combustion	Operation of on-Site equipment	Thermal Oxidizer	1 natural gas thermal oxidizer operates for 24 hours per day, 30 days per month for 6 months (1,481 hourly fuel use).
	On-Site Mobile Combustion	Operation of on-Site equipment	Forklift (Hp 100-175)	Forklift operates for 8 hours per day, 15 days per month for 1 month and travels 40 miles roundtrip to the site.
			Drill Rig (Hp 750-1000)	Drill rig operates for 12 hours per day, 15 days per month for 2 months and travels 40 miles roundtrip 2 times to the site.
			Cement/Mortar Mixer (Hp 100-175)	Cement/mortar mixer operates 8 hours per day, 15 days per month for 1 month and travels 40 miles roundtrip to the site.
	Off-Site Mobile Combustion	Transportation of workers	Environmental Engineer	1 environmental engineer travels 740 miles roundtrip to the Site by airplane two times.
			Engineering Manager	2 engineering managers work 10 days a month for 3 months and travel 35 miles roundtrip to the Site each day by passenger vehicle (gasoline).
			Environmental Scientists	2 environmental scientists work 20 days a month for 8 months and travel 35 miles roundtrip to the Site each day by passenger vehicle (gasoline).
			Earth Drillers	2 earth drillers work 20 days a month for 2 months and travel 35 miles roundtrip to the Site by heavy-duty truck (diesel).
			Construction Managers	1 construction manager works 20 days a month for 2 months and travels 35 miles roundtrip to the Site each day by passenger vehicle (gasoline).
		Transportation of raw materials	Transportation of Cement	5 loads transported 35 miles roundtrip by heavy-duty truck (diesel).
			Transportation of Steel	5 loads transported 35 miles roundtrip by heavy-duty truck (diesel).
			Transportation of Gravel, Bentonite, Steel Screening	5 loads transported 35 miles roundtrip by heavy-duty truck (diesel).
			Transportation of Caustic Solution	4 loads transported 35 miles roundtrip by light-duty truck (diesel).
		Transportation of waste	Transportation of Soil	25 loads transported 64 miles roundtrip by heavy-duty truck (diesel).
	On-Site Indirect Emissions	On-Site electricity use	Electrodes/Steam Injection	Electrodes/steam injection requiring 10,130 kW, 8 hours per day, 20 days per month for 6 months.
			Generator	2 generators requiring 20 kW, 8 hours per day, 20 days per month for 6 months.
			Air Stripper	1 air stripper requiring 5 kW, 8 hours per day, 20 days per month for 6 months.
	Raw Material Manufacturing	Raw material requirements for Site activities	Cement	46 cubic yards of cement are required.
			Gravel	76,948 pounds of gravel are required.
			Steel	88 tons of steel are required.
			Caustic Solution	200,000 pounds of caustic solution are required.
			Bentonite Pellets	1 cubic yard of bentonite pellets is required.

Notes:
The assumptions are based on conceptual level designs of the remedial alternatives that may be revised once a remedial alternative is selected.

TABLE E-2
CARBON FOOTPRINT FOR DIFFERENT ALTERNATIVES
PHOENIX-GOODYEAR AIRPORT-NORTH SUPERFUND SITE

Alternative	Type of Emissions	Emissions
Alternative 1 - No Action	On-site NOx, SOx, and PM emissions (lbs)	0
	On-site HAP emissions (lbs)	0
	Total NOx, SOx, and PM emissions (lbs)	0
	Total HAP emissions (lbs)	0
	Total greenhouse gas emissions (tons CO_2e)	**0**
Alternative 2 - In-well air stripping (IWAS) and hydraulic barrier	On-site NOx, SOx, and PM emissions (lbs)	5,545
	On-site HAP emissions (lbs)	0
	Total NOx, SOx, and PM emissions (lbs)	16,305
	Total HAP emissions (lbs)	204
	Total greenhouse gas emissions (tons CO_2e)	**1,032**
Alternative 3 - Anaerobic reductive dechlorination (ARD) and hydraulic barrier	On-site NOx, SOx, and PM emissions (lbs)	5,491
	On-site HAP emissions (lbs)	0
	Total NOx, SOx, and PM emissions (lbs)	11,518
	Total HAP emissions (lbs)	35
	Total greenhouse gas emissions (tons CO_2e)	**1,066**
Alternative 4 - Nano-scale zero valent iron (nZVI), ZVI, ARD, and hydraulic barrier	On-site NOx, SOx, and PM emissions (lbs)	5,330
	On-site HAP emissions (lbs)	0
	Total NOx, SOx, and PM emissions (lbs)	29,939
	Total HAP emissions (lbs)	284
	Total greenhouse gas emissions (tons CO_2e)	**2,689**
Alternative 5 - ZVI, ARD, and hydraulic barrier	On-site NOx, SOx, and PM emissions (lbs)	5,330
	On-site HAP emissions (lbs)	0
	Total NOx, SOx, and PM emissions (lbs)	18,165
	Total HAP emissions (lbs)	156
	Total greenhouse gas emissions (tons CO_2e)	**1,518**
Alternative 6 - In-situ chemical oxidation (ISCO) using permanganate and hydraulic barrier	On-site NOx, SOx, and PM emissions (lbs)	5,330
	On-site HAP emissions (lbs)	0
	Total NOx, SOx, and PM emissions (lbs)	11,560
	Total HAP emissions (lbs)	39
	Total greenhouse gas emissions (tons CO_2e)	**871**
Alternative 7 - Electrical resistive heating with steam injection (ERH/Steam) and hydraulic control	On-site NOx, SOx, and PM emissions (lbs)	1,972
	On-site HAP emissions (lbs)	0
	Total NOx, SOx, and PM emissions (lbs)	135,146
	Total HAP emissions (lbs)	2,623
	Total greenhouse gas emissions (tons CO_2e)	**7,603**

TABLE E-3
ON-SITE WATER CONSUMPTION
PHOENIX-GOODYEAR AIRPORT-NORTH SUPERFUND SITE

ALTERNATIVE	Type of Use	Water Use (gpm)	Average Hours of Operation per Day	Average Days of Operation per Month	Average Number of Months in Operation	Total Water Consumption (gallons)
Alternative 1 - No Action	No water consumption					
Alternative 2 - In-well air stripping (IWAS) and hydraulic barrier	Decontamination	5	1	5	5	7,500
Alternative 3 - Anaerobic reductive dechlorination (ARD) and hydraulic barrier	Decontamination	5	1	10	5	15,000
Alternative 4 - Nano-scale zero valent iron (nZVI), ZVI, ARD, and hydraulic barrier	Injection	1,000	10	1	1	600,000
	Decontamination	5	1	10	5	15,000
Alternative 5 - ZVI, ARD, and hydraulic barrier	Injection	1,000	10	1	1	600,000
	Decontamination	5	1	10	5	15,000
Alternative 6 - In-situ chemical oxidation (ISCO) using permanganate and hydraulic barrier	Injection	22,917	1	1	1	1,375,020
	Decontamination	5	1	10	5	15,000
Alternative 7 - Electrical resistive heating with steam injection (ERH/Steam) and hydraulic control	Steam Injection	25	8	20	6	1,440,000
	Decontamination	5	1	10	6	18,000

Notes:
gpm = gallons per minute
Decontamination activities require potable water
Non-potable water used for injection and steam injection

TABLE E-4
GROUNDWATER EXTRACTION
PHOENIX-GOODYEAR AIRPORT-NORTH SUPERFUND SITE

ALTERNATIVE	Number of Wells	Average Flow (gpm)	Average Hours of Operation per Day	Average Days of Operation per Month	Average Number of Months in Operation	Estimated Groundwater Extracted (gallons)
Alternative 1 - No Action	No groundwater extracted					
Alternative 2 - In-well air stripping (IWAS) and hydraulic barrier	3	65	8	30	48	44,928,000
Alternative 3 - Anaerobic reductive dechlorination (ARD) and hydraulic barrier	3	65	8	30	48	44,928,000
Alternative 4 - Nano-scale zero valent iron (nZVI), ZVI, ARD, and hydraulic barrier	3	65	8	30	48	44,928,000
Alternative 5 - ZVI, ARD, and hydraulic barrier	3	65	8	30	48	44,928,000
Alternative 6 - In-situ chemical oxidation (ISCO) using permanganate and hydraulic barrier	3	65	8	30	48	44,928,000
Alternative 7 - Electrical resistive heating with steam injection (ERH/Steam) and hydraulic control	3	65	8	30	48	44,928,000

Notes:
gpm = gallons per minute

TABLE E-5
RAW MATERIAL CONSUMPTION
PHOENIX-GOODYEAR AIRPORT-NORTH SUPERFUND SITE

ALTERNATIVE	ACTIVITY	INPUT
Alternative 1 - No Action	No raw material consumption	
Alternative 2 - In-well air stripping (IWAS) and hydraulic barrier	Cement	77 cubic yards
	Gravel	121,500 pounds
	Steel	1,040 pounds
	PVC	48,034 pounds
	Bentonite Pellets	1 cubic yard
Alternative 3 - Anaerobic reductive dechlorination (ARD) and hydraulic barrier	Cement	123 cubic yards
	Gravel	35,100 pounds
	Steel	720 pounds
	PVC	24,521 pounds
	Bentonite	106 cubic yards
	Bioaugmentation	1,280 liters
	Emulsified Oil	214,830 pounds
Alternative 4 - Nano-scale zero valent iron (nZVI), ZVI, ARD, and hydraulic barrier	Cement	110 cubic yards
	Gravel	16 cubic yards
	Steel	880 pounds
	PVC	22,667 pounds
	Bentonite	89 cubic yards
	Zero-Valent Iron	1,604,016 pounds
	Bioaugmentation	1,080 liters
	Liquid Nitrogen	1,275 liters
	Emulsified Oil	120,120 pounds
	Nano-Scale Zero-Valent Iron	133,560 pounds
Alternative 5 - ZVI, ARD, and hydraulic barrier	Cement	146 cubic yards
	Gravel	13 cubic yards
	Steel	720 pounds
	PVC	28,741 pounds
	Bentonite	129 cubic yards
	Zero-Valent Iron	808,500 pounds
	Bioaugmentation	1,080 liters
	Liquid Nitrogen	1,275 liters
Alternative 6 - In-situ chemical oxidation (ISCO) using permanganate and hydraulic barrier	Cement	124 cubic yards
	Gravel	21 cubic yards
	Steel	1,200 pounds
	PVC	22,712 pounds
	Bentonite	96 cubic yards
	Permanganate	289,606 pounds
Alternative 7 - Electrical resistive heating with steam injection (ERH/Steam) and hydraulic control	Cement	46 cubic yards
	Gravel	76,948 pounds
	Steel	88 tons
	Caustic Solution	200,000 pounds
	Bentonite Pellets	1 cubic yard

Notes:
PVC - Polyvinyl Chloride

TABLE E-6
SOLID WASTE GENERATION
PHOENIX-GOODYEAR AIRPORT-NORTH SUPERFUND SITE

ALTERNATIVE	ACTIVITY	Weight
Alternative 1 - No Action	No solid waste generated	
Alternative 2 - In-well air stripping (IWAS) and hydraulic barrier	Non-hazardous Soil	234 tons
Alternative 3 - Anaerobic reductive dechlorination (ARD) and hydraulic barrier	Non-hazardous Soil	374 tons
Alternative 4 - Nano-scale zero valent iron (nZVI), ZVI, ARD, and hydraulic barrier	Non-hazardous Soil	330 tons
Alternative 5 - ZVI, ARD, and hydraulic barrier	Non-hazardous Soil	440 tons
Alternative 6 - In-situ chemical oxidation (ISCO) using permanganate and hydraulic barrier	Non-hazardous Soil	380 tons
Alternative 7 - Electrical resistive heating with steam injection (ERH/Steam) and hydraulic control	Non-hazardous Soil	350 tons
	PVC (Non-hazardous)	2.5 tons

Notes:
PVC = polyvinyl chloride

TABLE E-7
LIQUID WASTE GENERATION
PHOENIX-GOODYEAR AIRPORT-NORTH SUPERFUND SITE

Alternative	Volume of Liquid Waste (gallons)
Alternative 1 - No Action	No liquid waste generated
Alternative 2 - In-well air stripping (IWAS) and hydraulic barrier	8,500
Alternative 3 - Anaerobic reductive dechlorination (ARD) and hydraulic barrier	17,900
Alternative 4 - Nano-scale zero valent iron (nZVI), ZVI, ARD, and hydraulic barrier	13,500
Alternative 5 - ZVI, ARD, and hydraulic barrier	26,300
Alternative 6 - In-situ chemical oxidation (ISCO) using permanganate and hydraulic barrier	14,650
Alternative 7 - Electrical resistive heating with steam injection (ERH/Steam) and hydraulic control	7,500

TABLE E-8
SUSTAINABILITY EVALUATION SUMMARY
PHOENIX-GOODYEAR AIRPORT-NORTH SUPERFUND SITE

Output	Unit	Alternative 1 No Action	Alternative 2 IWAS + Hydraulic Barrier	Alternative 3 ARD + Hydraulic Barrier	Alternative 4 nZVI + ZVI + ARD + Hydraulic Barrier	Alternative 5 ZVI + ARD, + Hydraulic Barrier	Alternative 6 ISCO + Hydraulic Barrier	Alternative 7 ERH +Steam + Hydraulic Control
Total Greenhouse Gas Emissions	tons CO_2e	0	1,032	1,066	1,689	1,518	871	7,603
Total NO_x, SO_x, and PM Emissions	lbs	0	16,305	11,518	29,939	18,165	11,560	135,146
Total HAP Emissions	lbs	0	204	35	284	156	39	2,623
Potable Water Consumption	gallons	0	7,500	15,000	615,000	615,000	1,390,020	1,458,000
Groundwater Injection	gallons	0	0	0	600,000	600,000	1,375,020	1,440,000
Groundwater Extraction	gallons	0	44,928,000	44,928,000	44,928,000	44,928,000	44,928,000	44,928,000
Raw Material Consumption	tons	0	183	301	1,109	631	347	285
Non-Hazardous Solid Waste Production	tons	0	234	374	330	440	380	350
Wastewater Production	gallons	0	8,500	17,900	13,500	26,300	14,650	7,500

Notes:
HAP = hazardous air pollutant
NO_x = nitrogen oxides
PM = particulate matter
SO_x = sulfur oxides