62-087-00015 8.1

REPORT

REVISED FEASIBILITY STUDY REPORT FOR THE FORMER BOEING WICHITA FACILITY WICHITA, KANSAS

Submitted to: Kansas Department of Health and Environment
Bureau of Environmental Remediation/Site Remediation Unit
1000 SW Jackson, Suite 410
Topeka, Kansas 66612 USA

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2 copies – Golder Associates Inc.

April 2010

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Robert Moser, MD, Secretary Department of Health & Environment Sam Brownback, Governor

September 23, 2011

Mike Spain
The Boeing Company
2727 East MacArthur
Wichita, Kansas 67216

**RE: Boeing Commercial Aircraft Group Site
Wichita, Kansas
Review of the *Revised Feasibility Study Report***

Dear Mr. Spain:

The Kansas Department of Health and Environment (KDHE) has completed its review of the *Revised Feasibility Study Report* (Revised FS Report), received by KDHE on April 20, 2010. Golder Associates, Inc. (Golder) prepared the Revised FS Report on behalf of The Boeing Company (Boeing) for the Boeing Main Site (Site). The Revised FS Report corresponded to work related to requirements contained in the letters from KDHE to Boeing, dated July 27, 2009, and March 1, 2010. As you are aware, completion of our review had been pending until reaching tentative agreement recently on an acceptable approach for the 31st and Clifton area.

KDHE's review of the Revised FS Report was based on the information submitted. The Revised FS Report will be used as the general basis for KDHE's draft Corrective Action Decision (CAD) to be made available for public comment. With consideration of any public comment received during the public comment period, KDHE will issue a final CAD, implementation of which will be incorporated in the new Consent Order. KDHE approves the Revised FS Report with consideration of the following comments:

1. For the record, KDHE notes that chromium is a site-related contaminant of concern (COC) and is discussed in the text and tables of the Revised FS Report but, as would otherwise be expected, the distribution of chromium is not depicted in a report figure. However, because chromium distribution is adequately represented in Boeing's most recent semi-annual report submittal, no additional figure is needed for the Revised FS Report.

2. Monitored Natural Attenuation (MNA) is described as a provisional element of the Alternative 4 remedial strategy. If Alternative 4 is identified as the preferred remedy by KDHE in the draft CAD and eventually selected as the final remedy for the Site, please be advised that MNA must be demonstrated to occur in the areas of interest in accordance with KDHE-Bureau of Environmental Remediation (BER) Policy No. BER-RS-042 *Monitored Natural Attenuation* which is available on the KDHE website at: http://www.kdheks.gov/ber/policies/BER_RS_042.pdf. Although generally preferable to determine the viability of MNA in advance of final remedy selection, KDHE is agreeable to the provisional determination approach suggested by Boeing. KDHE notes that alternative contingency plans are described should any of the proposed remedial measures be considered not effective.

3. Several sections of the Revised FS report refer to the Alternate Cleanup Levels (ACLs) calculated by KDHE in May 1999. Since that time, the toxicity data for some of the site-related COCs have been reevaluated and updated as reflected in the *Risk-Based Standards for Kansas RSK Manual* – 5th Version (2010) based on the current toxicological values presented in the U.S. Environmental Protection Agency Integrated Risk Information System (IRIS). Therefore, updated ACLs based on the new toxicity data should be calculated. KDHE-BER current policy allows for consideration of Alternative Treatment Goals (ATGs) for the source areas and those portions of the Site where the contamination is mitigated/managed through hydraulic containment. Please refer to KDHE-

BER Policy No. BER-RS-28, *Consideration for Hydraulic Containment* which addresses the situations under which ATGs may be calculated and considered for a site (http://www.kdheks.gov/ber/policies/BER_RS_028.pdf). However, please be advised that ATGs are not to be used in calculation of vapor intrusion threshold levels for COCs as indicated in KDHE-BER Policy No. BER-RS-45 *Considerations for Groundwater Use and Applying RSK Standards to Contaminated Groundwater* available at http://www.kdheks.gov/ber/policies/BER_RS_045.pdf. Instead, the corresponding KDHE Tier 2 Levels should be used to assess whether or not and to what degree vapor intrusion is occurring at the Site.

4. Appendix A, Summary of Source Characterization, Nature and Extent Investigation, and Interim Remedial Measures presents various measures that were applied to different areas of the Boeing Main Site including the Englewood area. In July 2004, KDHE and Boeing agreed that the delineation of a zero contamination line within the Englewood area was sufficiently bounded. However, this determination was made prior to the more recent recognition of the potential for vapor intrusion from volatile organic compounds in groundwater into indoor air. With consideration of the vapor intrusion results from the nearby 31st and Clifton Site it may be necessary to reassess contaminant distribution in groundwater within the Englewood area.

5. KDHE notes that additional source control interim measures (IMs) have occurred at the Boeing Main Site since the submission of the Revised FS Report. These IMs have included excavation of source material, in situ bioremediation, and zero valent iron injections. These IMs are alluded to in the Revised FS Report as proposed components of the overall remedial strategy for the Site and will be fully described in the draft CAD.

Should you have any questions or concerns regarding this letter, you may reach me by telephone at 785-296-1936 or by e-mail at mtownsend@kdheks.gov.

Sincerely,

Margaret Townsend

Margaret Townsend, LG
Environmental Scientist
Remedial Section/Site Remediation Unit
Bureau of Environmental Remediation

c: Rick Bean, KDHE → E. Jean Underwood, KDHE → Boeing Commercial Aircraft (C2-087-00015) 1.0
Eric Kern, Golder Associates, Inc.

KANSAS

DEPARTMENT OF HEALTH
AND ENVIRONMENT

Division of Environment

Mark Parkinson, Governor
Roderick L. Bremby, Secretary

www.kdheks.gov

July 12, 2010

Mike Spain
The Boeing Company
2727 East MacArthur
Wichita, Kansas 67216

RE: Boeing Commercial Aircraft Group Site
Wichita, Kansas
Review of the *Revised Feasibility Study Report*

Dear Mr. Spain,

The Kansas Department of Health and Environment - Bureau of Environmental Remediation (KDHE - BER) has completed its review of the *Revised Feasibility Study Report* (Revised FS Report), received by KDHE-BER on April 30, 2010. Golder Associates Inc. (Golder) prepared the Revised FS Report on behalf of The Boeing Company (Boeing). The Revised FS Report corresponded to work related to requirements contained in the letters from KDHE-BER to Boeing, dated July 27, 2009, and March 1, 2010.

KDHE-BER=s review of the Revised FS Report was based on the information submitted. The FS Report will be used as the basis for KDHE-BER's Corrective Action Decision (CAD), implementation of which will be incorporated into the new Consent Order. KDHE-BER provides the following comments on the Revised FS Report. Approval and acceptance of the FS Report into the administrative record will be granted once the following comments have been adequately addressed.

General Comment

Other than being minimally mentioned in the Revised FS Report, the 31st and Clifton and K-15 Springs areas are not discussed. Because KDHE-BER considers these areas as part of the overall "Site", the Revised FS Report also needs to include pertinent discussion and information regarding the interim remedial measures, proposed corrective actions, and prospective corrective actions that have been implemented or are proposed for these areas. Please incorporate this information accordingly.

Because chromium is a site-related contaminant of concern, the FS Report also needs to include figures showing the distribution of chromium in groundwater on the Boeing facility.

Specific Comments

Table 3. This table provides a summary of screening factors for numerous potential remedial technologies that were evaluated as part of the FS. However, no cost ranges were provided, only a relative evaluation (i.e., low, medium, high) of costs were provided. Please revise the information in Table 3 to include a cost range (in U.S. Dollars) for each of the alternatives evaluated and presented in Table 3.

Additionally, in the "Specific Considerations for Boeing Site" column for Remedy Number 10, the text in the corresponding cell appears to be truncated (e.g., the word "Limited" is the last word in the cell of the table). Please revise the text appropriately.

Please prepare and submit a Revised FS Report (addressing the above comments) to KDHE-BER by August 16, 2010. Should you have any questions regarding this letter, you may reach me by telephone at 785-291-3066 or by e-mail at sbryant@kdheks.gov.

Sincerely,

Steve Bryant
Professional Geologist
Remedial Section/Site Remediation Unit
Bureau of Environmental Remediation

c: E. Jean Underwood→file Boeing Commercial Aircraft Group Site (C2-087-00015-01)
Eric Kern, Golder Associates Inc.

1.0 INTRODUCTION

In 1985, the Boeing Company (Boeing) identified trichloroethylene (TCE) in groundwater at the Boeing Wichita facility (referred to herein as the facility or the Site) during a property assessment of a parcel of land purchased from the Cessna Aircraft Company (Cessna). Subsequently, in 1986 the Kansas Department of Health and Environment (KDHE) and Boeing negotiated into a Consent Order 87-E-12 (CO) for the cleanup of the subsurface under the facility. The KDHE CO (which was amended in 1992 and 2001) requires Boeing to install and operate a groundwater treatment system to remediate subsurface contamination at the facility, a remedy that is currently still in place and operating (with approved minor modifications over the years).

On July 27, 2009, Boeing received a letter from KDHE indicating the need to update the current administrative framework for investigation and remediation activities at the facility. KDHE further indicated that since a Corrective Action Decision (CAD) has not been completed for the facility, the CO must be amended or a new CO issued to satisfy current KDHE programmatic requirements. KDHE identified the following three tasks to be completed by Boeing before an amendment or new CO is developed:

- Vapor Intrusion Investigation Work Plan;
- Groundwater Monitoring and Recovery Well Optimization, including an "Optimization Work Plan"; and
- Feasibility Study (FS) Revisions.

The Vapor Intrusion Investigation Work Plan and Optimization Work Plan (Golder, 2009d) have been completed and submitted to KDHE. This Revised Feasibility Study (RFS) report consists of the Feasibility Study Revisions requested by KDHE to present "information on the interim remedial measures that have been implemented at the various sites within the Boeing facility." This RFS report has been developed based on information and data provided by Boeing and in conjunction with Tom Hansen of Bittersweet Energy, Inc.

1.1 Project Scope

The project scope is based on the standard KDHE list of Corrective Action work items, in addition to conversations between KDHE, Boeing, and Golder. Feasibility Studies were previously conducted for the Site in 1986 (Boeing Environmental Engineering, 1986 and Mid West Analytical, 1986). Substantial Site characterization activities and Interim Remedial Measures (IRMs) have been performed at the Site consistent with the CO. KDHE requested that an RFS be prepared to summarize the IRM that have been implemented and build upon previous work at the Site to develop an approach for future Site remedial activities.

As requested by KDHE, this RFS presents a focused evaluation of remedial alternatives, since previous implementation of IRMs at the Site has allowed for empirical evaluation and demonstration of effectiveness. Based on discussions with KDHE, the goal of this RFS report is to provide a summary of previous IRMs and present a strategy for future remedial activities, and to provide this decision-oriented rationale in as streamlined a manner as practical.

As requested, this RFS report presents IRMs implemented under the CO at the Site; however, additional remedial activities have also been conducted at the Site to address petroleum hydrocarbon contamination. Oversight of these activities was through the KDHE South Central District Storage Tank Section. Removal of Underground Storage Tanks (USTs) was conducted from the mid 1980s through the mid 1990s. Contaminated soil associated with removal of USTs and buried piping was excavated and either sent off-site for disposal or remediated on-site at a landfarm.

Below, this RFS provides in Section 2 the Site background information (including previous site investigations and IRMs), the Site setting (including geological, hydrological, and chemical characterizations) and the Remedial Action Objectives and Applicable and Relevant and Appropriate Requirements for the Site. Section 3 provides a description of remediation alternates for the Site. Section 4 provides an evaluation of remediation alternatives (as gauged against the nine (9) National Contingency Plan (NCP) criteria). Following KDHE recommendations, Section 4 (evaluation of alternatives) is presented in a focused and generalized manner, with a significant portion of the details provided in Table format.

Sections 5 and 6 provide recommendations and references, respectively.

2.0 BACKGROUND INFORMATION

2.1 Site Location

Boeing owned and operated a facility at 3801 South Oliver in Wichita, Kansas (Figure 1), which was referred to as the Boeing Wichita Facility. Boeing sold the commercial operations and retained the Boeing Defense, Space and Security (BDS) operations in June 2005 to Spirit AeroSystems (Spirit), at which point the facility was referenced in reports to KDHE as the Former (commercial) Boeing Wichita Facility. Boeing currently owns and operates 506 acres at the BDS facility located at 4615 South Oliver in Wichita, Kansas. The remediation activities described herein are located on the property that was sold; no remediation activities exist on the current BDS property.

2.2 Site History

Contamination was first discovered by The Boeing Company in October 1985 during an environmental investigation on the Cessna Plant II Facility, which was being acquired by Boeing. During the investigation six soil borings were installed. Soil samples were collected from the six borings and one groundwater grab sample was obtained. Analysis of the soil samples did not indicate any evidence of chemical contamination, but the water sample indicated the presence of TCE. Boeing expanded the investigation to confirm the findings and define the extent of the TCE contamination. Mid West Analytical Laboratories was contracted to conduct a second phase of drilling. Six additional borings were installed on the Cessna property and water samples were collected on December 5, 1985. Two of the borings were completed as monitoring wells. The water analysis received on December 13, 1985 confirmed the presence of solvents in the groundwater. Boeing installed four borings on Boeing property adjoining the east side of the Cessna property upon discovery of the contamination present on the Cessna property. Groundwater samples from these borings indicated the presence of TCE contamination on Boeing property. Boeing notified KDHE of the findings on January 2, 1986. The KDHE CO was issued to Boeing from KDHE on January 10, 1986.

TCE degreasing operations were determined to be the primary source of the TCE groundwater contamination. As a result of this finding, Boeing built a new state of the art facility (over 1 million square feet) to house chemical processing. The Manufacturing Process Facility (MPF) Building has the process tanks on the second floor and above ground containment on the first floor of the building. The base of the tanks and containment are inspected daily, thus minimizing any future contamination at the Boeing Site. All containment areas are inspected daily and kept free of liquids.

2.3 Interim Remedial Measures

A detailed summary of IRMs is provided as Appendix A of this report, and an overview of the IRMs is presented in Table 1. A brief description of IRMs is provided below. 1987, 55 groundwater extraction wells were installed per the KDHE CO. Four recovery wells began extraction of groundwater during the late summer of 1986 to prevent the offsite migration of contaminants to the North Creek area. From 1987 through 1991 additional investigations were completed to evaluate potential source areas and property assessments. In 1991 all previous geologic data was correlated, surveyed, and compiled into a Site-wide geologic report. With this information, the groundwater remediation system was expanded along the property boundary to further contain the contamination in 1992. Additional groundwater remediation systems were installed in 1993 and 1994 to address the known source areas or "hot spots." Several additional remedial systems were installed in 1996 and 1997 (K-15 Springs, D-9, and IPB2 systems) and in 2002 (31st and Clifton system, the IAM Union system). Dual phase extraction was incorporated into the existing groundwater remediation system in 1997.

Boeing has installed over 800 borings, monitoring wells, and recovery wells at the Site since 1985. At the present time Boeing operates approximately 211 recovery wells, 195 monitoring wells, and 9 air stripper sites to comply with the KDHE CO. A full time contractor checks the groundwater systems on a daily basis and assures all maintenance and repairs are completed. Groundwater samples are collected during the first quarter of each year from selected monitoring and recovery wells and a report is submitted to KDHE. All recovery wells and monitoring wells are sampled during the 4th quarter of each year and an analytical report is submitted to KDHE. An annual report is prepared on or before March 1 of each year updating the KDHE on the progress of remediation efforts at the Site during the previous year. Index monitoring wells are sampled monthly to monitor the progress of remediation at the Site. Boeing continues to delineate contamination at the Site and improve the efficiency of the recovery system.

In situ accelerated bioremediation programs are currently in operation at the 500 Ramp and Plant 2 areas of the Site. Monitoring data has demonstrated the effectiveness for treatment of chlorinated ethenes, and preliminary data indicates the effectiveness in reduction of hexavalent chromium. A pilot test program for injection of zero-valent iron (ZVI) was completed in the Englewood Area of the Site. The program demonstrated effectiveness in reduction of chlorinated ethenes; however, the distribution of the ZVI particles appeared to be relatively limited.

Source remediation has occurred throughout the life of the groundwater remediation program with removal and disposal of contaminated soil encountered during construction projects, demolition projects, or any potential source area investigations.

2.4 Geology and Hydrogeology

2.4.1 Regional Geology

The Site is located in the Arkansas River Lowland (or Great Bend Lowland) in Sedgwick County, about five miles south of downtown Wichita, Kansas (see Figure 1). The Arkansas River Lowland is described as a flat, smooth plain that drains to the Arkansas River (Bevins, 1989).

2.4.2 Site Geology

The Site vicinity is underlain at the surface by unconsolidated deposits of loess (silt with caliche nodules and sand) and the Arkansas River Valley fill (fluvial sands) (Bevins, 1989). Permian age bedrock of the Wellington formation underlies the unconsolidated deposits. The Wellington Formation consists of "gray and blue shale with small, thin beds of maroon shale, impure limestone, gypsum, and anhydrite" (Bevins, 1989). A detailed discussion of Site Geology is presented in the report titled "3-D Groundwater Flow Model for the Boeing Facility, Wichita, Kansas," prepared by Beatty Franz Associates (BFA, 1998). BFA summarized site geology in terms of four geologic units:

- Brown clay: surface deposits of loess silts and clays;
- Fluvial deposits: relatively higher transmissivity sand, sandstone, silty sand, and clayey sand;
- Olive clay: weathered Wellington Shale; and
- Wellington Shale bedrock.

Geological cross sections illustrating Site lithology are provided in the 3-D Groundwater Flow Model (Beatty Franz Associates, 1998). Golder's conceptual interpretation of these sections (as defined in the recent MODFLOW model, Golder, 2009d) is provided on Figure 2.

2.4.3 Site Hydrogeology

The Site receives groundwater from precipitation recharge (precipitation minus runoff and evapotranspiration losses), groundwater inflow from adjacent areas, and losing stream reaches. The aquifer in the Site vicinity discharges groundwater to the Arkansas River and its tributaries.

The climate of the Arkansas River Lowland is continental, with approximately 30 inches of annual rainfall. The majority of annual rainfall (approximately three quarters) occurs between the months of April and September. However, Bevins (1989) indicated that the majority of groundwater recharge likely occurs during late winter and early spring due to diminished evapotranspiration during this time.

Groundwater at the Site is generally encountered at a depth of 15 to 25 feet below ground surface (bgs). Groundwater flow occurs in the interbedded sand units in the aquifer, which are not continuous throughout the Site. The majority of aquifer materials encountered in the Site vicinity typically exhibit low hydraulic conductivities. Relatively thin layers of sandy, higher hydraulic conductivity, fluvial deposits are observed in several borings just above the weathered bedrock surface of the Wellington Shale. The high contrast in hydraulic conductivity between the sand layers, overlying silts/clays and the underlying shale may create a condition such that the sand layers and the underlying bedrock surface exert a strong influence on groundwater flow and contaminant transport. The geometry of the sand layers will exert a strong local influence on the movement of groundwater and contaminants. The location and geometry of the sand units at the Site, as defined by borehole logs, have been previously described (Golder, 2009).

2.4.4 Hydraulic Conductivity Testing

BFA (1998) summarized historic aquifer test analysis results for Site monitoring and recovery wells in terms of the four geologic materials presented in Section 2.3.2. Golder interpreted these aquifer test results, as summarized in Appendix A, to assign initial model hydraulic conductivity values to Site Aquifer materials. According to BFA, the average calculated hydraulic conductivities were:

- Between 1.75×10^{-4} to 1.29×10^{-3} cm/s (0.50 to 3.7 ft/day) for wells screened in the brown clay materials;
- Between 7.11×10^{-4} to 1.95×10^{-2} cm/s (2.0 to 32 ft/day) for wells screened in the fluvial materials; and
- Between 2.76×10^{-5} to 1.27×10^{-3} cm/s (0.080 to 3.7 ft/day) for wells screened in the olive clay materials.

Aquifer testing was also performed at the Glickman area of the Site in May 1992 by Bittersweet Energy, Inc. This aquifer testing was conducted to determine the appropriate spacing between recovery wells necessary to achieve groundwater capture. The test wells were located near MW-111 and were completed in the fluvial unit described above. Water levels were measured over time at the pumped well and three observation wells during the 25-hour pumping test. The pumping rate during the test was approximately 7 gallons per minute (gpm) or less. The recovery data was analyzed using the Cooper-Jacob method. Calculated hydraulic conductivity values at the pumped well and observation wells ranged from 3.28×10^{-3} cm/s to 5.74×10^{-3} cm/s, with an average value of 4.47×10^{-3} cm/s.

Radius of influence based on the distance drawdown plot ranged from 145 ft (100 minutes) to 250 ft (1500 minutes). Based on the aquifer test results, a distance of 150 ft between recovery wells has been used since May 1992 at the Site to provide for groundwater capture.

2.4.5 Conceptual Hydrogeologic Model

The Site hydrogeologic conceptual model is controlled by silt, sand, and clay aquifer materials overlaying bedrock and weathered bedrock (gray clay) aquicludes. The aquifers are recharged primarily by precipitation recharge during late winter and early spring (Bevins, 1989). The Site hydrogeologic model is also influenced by the Boeing remedial extraction system. Aquifers are predominantly fluvial sands and silts, loess silts/clays and weathered bedrock clays. Groundwater generally flows from northeast to southwest with components of flow to the west and northwest in areas of the model.

2.4.6 Evaluation of Groundwater Capture

As discussed above, a groundwater extraction and treatment system has been implemented at the Site as an IRM. A groundwater flow model was developed, in part, to evaluate and optimize the effectiveness of this system. As discussed in the Optimization Work Proposal (OWP) (Golder, 2009), Golder completed an evaluation of Site-wide capture of the existing recovery well system using the Modular Three-Dimensional Finite-Difference Groundwater Flow Model (MODFLOW; MacDonald and Harbaugh,

1988) and MODPATH (Pollack, 1989) simulation codes. The Site-wide groundwater capture evaluation was completed by placing particles in portions of the model with known or historic groundwater impacts and creating flow paths for these particles.

The MODPATH simulations indicated that the Boeing recovery well system captured the majority of the placed particles, with the exception of one of the 30 particles placed in the Plant 1 vicinity that was not captured by the modeled recovery well network. This particle ends up in the vicinity of the K-15 drain system. The un-captured particle travels under Boeing North Lake between the Industrial Waste Treatment Plant (IWTP) wells and Materials wells in the vicinity of MW-006A, MW-081, and MW-096. Recent analytical results from MW-006A, MW-081 and MW-096 did not detect VOCs above analytical reporting limits, suggesting that the existing recovery well network is providing capture in this area. The MODPATH particle trace analysis results indicated that the existing recovery well network is capable of capturing groundwater originating from under the Site.

2.5 Groundwater Geochemistry

Boeing has provided KDHE with annual reports documenting the results of the groundwater monitoring program at the Site. These reports (referenced in Section 5) provide detailed characterization of the nature and extent of contaminants of concern (COCs). In addition, Appendix A provides a detailed summary of source characterizations, nature and extent investigations, and interim remedial measures performed to date. Therefore, this section provides only a brief overview of groundwater chemistry for the Site.

Historically, petroleum hydrocarbons were observed within several areas of the Site; however, many of these areas have been previously remediated (as discussed in Section 3.7). The primary VOCs currently observed in groundwater at the Site are chlorinated ethenes (including tetrachloroethene [PCE], TCE, cis-1,2-dichloroethene [cDCE], and vinyl chloride [VC]) and chlorinated methanes (including carbon tetrachloride [CT] and chloroform). TCE was used as an industrial solvent at the Site and is the predominant chlorinated ethene at this Site. The occurrence of TCE often corresponds to the location of vapor degreasers used in historic operations at the Site (as shown in Figure 3). Microbial dechlorination processes have resulted in substantial transformation of TCE to daughter products including cDCE and VC within discrete areas of the Site, often where occurrence of petroleum hydrocarbons served as electron donors to support the degradation process. Hexavalent chromium is also present in groundwater within areas of the Site. The occurrence of hexavalent chromium in groundwater at the Site often corresponds to the location of a pipeline for the IWTP system (as shown in Figure 4).

The VOCs and hexavalent chromium observed in groundwater at the Site are present within the brown clay, fluvial deposits and olive clay overlying the Wellington Shale bedrock. The fluvial deposits are the primary mechanism for transport and groundwater recovery wells. Groundwater monitoring and recovery wells typically have screened intervals that extend across the brown clay, fluvial deposits and/or olive clay units. Numerous site assessment activities have been conducted over time, which are presented in Appendix A. A Zero-Line Investigation was initiated in 1993 to further delineate horizontal and vertical occurrence of contamination in groundwater (Boeing, 1993). This comprehensive investigation included installation of a total of approximately 200 boreholes, monitoring wells, and recovery wells, which furthered the understanding of the nature and extent of groundwater contamination at the Site. For example, six deep groundwater wells (MW-170, MW-171, MW-172, MW-173, MW-174, and MW-175) were completed as part of this investigation within the Wellington Shale in November 1993 to characterize the nature and extent of groundwater contamination (Boeing, 1994). Groundwater analytical data collected from these wells in November 1993 indicated that contaminant concentrations were below detection limits (MW-171, MW-173, and MW-175) or below MCLs (MW-170 and MW-172) with the exception of MW-174. Relatively low concentrations of TCE (7.6 ug/L) and cDCE (3.6 ug/L) were observed in monitoring well MW-174. These wells were abandoned in July and August 1994 to eliminate a potential conduit for contamination of deep groundwater (Boeing, 1994).

Mining Visualization System (MVS) software was used by Golder to model total volatile organic carbon (TVOC) data collected during the second semi-annual events in 1995 and 2008. Concentrations of TVOC include: carbCT, PCE, TCE, cDCE, and VC. Concentrations of TVOC for the second semi-annual events in 1995 and 2008 for data above 10 micrograms per liter (ug/l) are presented for discrete areas of the Site in Section 3. Mass is calculated by computing the volume of TVOC in each model cell based on a 25 percent porosity, then the mass of TVOC based on volume of contaminated liquid is integrated, then added together.

The database of approximately 800 plus borings was accessed to model the geology at the Boeing and the MAFB properties and was the framework and grid that the TVOC modeling used. In addition, water level measurements were used in each of the models to more accurately determine dissolved contaminant mass estimates for the 1995 and 2008 sampling events. Estimates of TVOC mass represent saturated-zone impacts only. The mass estimates for the dissolved state represent a snapshot in time based on concentrations of TVOC at specific wells in each network. The volume between each data point is logarithmically kriged. The mass removal rates shown below do not take into consideration on-Site remediation systems. The on-Site systems take into account vapor flow from air-sparge/SVE systems, fluctuations in water table moving through the vadose zone, and any areas of high concentrations that are pulled in by the groundwater extraction and treatment system.

The table below summarizes the data from each of the areas and shows the overall mass reduction. In general, mass reductions are between 23% (Plant 1) and 83% (South Campus), with an average of 39% across the entire facility.

Area Name	1995	2008	Percent Change
South Campus	125 kg	22 kg	83%
Plant 2	3,431 kg	2,476 kg	28%
Reclamation	201 kg	112 kg	44%
Plant 1	81 kg	62 kg	23%
Entire Site	4,472 kg	2,750 kg	39%

Natural attenuation indicator parameters have been sampled from numerous recovery wells and monitoring wells at the Site. The results of this analysis have indicated that the groundwater system often is characterized by relatively oxidizing conditions. For example, wells sampled in the vicinity of the Plant 2 Area had dissolved oxygen (DO) concentrations typically greater than 5 milligrams per Liter (mg/L), oxidation reduction potential (ORP) typically greater than 100 (millivolts) mV, the presence of potential electron acceptors including nitrate and sulfate, and the absence of detectable concentrations of sulfide. In addition, total organic carbon (TOC) concentrations were typically less than 2 mg/L.

While the Site groundwater system may be natural oxidizing, areas of strongly reducing geochemical conditions are also observed. This is typically the result of historic releases of petroleum hydrocarbons, which serve as electron donors for microbial respiration processes and drive the groundwater system anaerobic. For example, the 500 Ramp and Reclamation Sub Areas have strongly reducing groundwater conditions, which have subsequently resulted in substantial microbial dechlorination of TCE to cDCE, VC, and ethene.

2.6 Remedial Action Objectives

2.6.1 Remedial Action Objectives Development Process

Remedial action objectives (RAOs) for a site are media-specific environmental goals intended to facilitate the development of remedial alternatives that will be protective of human health and the environment. RAOs are developed by evaluating the risks to human health and the environment and identifying corresponding preliminary remediation goals (PRGs). Final remediation goals will be selected following the detailed analysis of alternatives.

The RAOs development process is based on the alternative development process outlined in the 1988 EPA "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (1988 EPA Guidance). This guidance indicates that "protectiveness may be achieved by reducing exposure (such as capping an area, limiting access, or providing an alternate water supply) as well as by reducing contaminant levels."

During the development process the following Site-specific information is evaluated for the Site and downgradient areas:

- The contaminants and media of concern;

- The exposure routes and receptor populations; and
- The remediation goals for each complete exposure pathway – The applicable and relevant and appropriate requirements (ARARs) established by promulgated federal and state laws and regulations.

The contaminants, media of concern, exposure routes, and receptor populations are part of the exposure pathway evaluation. An exposure pathway in general identifies the route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with it. When all parts of the exposure pathway are present, the exposure pathway is termed a completed exposure pathway. After the complete exposure pathways have been identified for the Site, the ARARs can be identified, and the RAOs can be selected.

2.6.2 Site Specific Remedial Action Objectives Evaluation

The Site-specific RAOs evaluation discusses each of the components of the exposure pathways (listed above) for the Site and the applicable ARARs.

2.6.2.1 Source(s) of Contamination

Sources of contamination at the Site have been identified and are presented in detail in Appendix A of this report. Sources are typically the result of historic releases from vapor degreasers and IWTP lines to subsurface soil and groundwater. Please refer to Appendix A for details regarding the known and suspected source areas on the facility. From these sources areas, the following COCs have been identified; chlorinated ethenes, chlorinated methanes, petroleum hydrocarbons and hexavalent chromium. The distribution of these COCs at the Site and downgradient areas is also discussed in detail in Appendix A.

Substantial activities have been undertaken to define the nature and extent of groundwater contamination and implement IRM to address both groundwater and soil contamination. In addition, the extent and concentration of the groundwater contamination have been significantly reduced due to the IRMs.

2.6.2.2 Environmental Media and Transport

Once contaminants are released from their source, they may be transported through several processes to various environmental media. The following transport processes and environmental media of concern have been identified as potentially applicable at the Site:

- **Groundwater Migration** – The groundwater transport processes of advection, dispersion, and diffusion have the potential to transport COCs dissolved in groundwater from source areas to downgradient locations. As described below, the existing groundwater extraction system has limited the extent of groundwater transport downgradient so that the dissolved phase groundwater plume dimensions (shown in Figure 5) are expected to be stable or to shrink.
- **Soil Leaching to Groundwater** – In areas where contaminated soil is present within the vadose zone, COCs may be leached to groundwater as precipitation infiltrates through

the vadose zone or as the groundwater table rises to come in contact with source areas during wet seasons. Whenever contaminated soil in the vadose zone has been encountered during Site construction/excavation projects, it has been removed, but there is some potential that contaminated vadose soil remains in other areas of the Site.

- **Discharge of Groundwater to Surface Water** – Groundwater recharging to surface water in gaining streams, seeps, or springs has the potential to transport COCs to surface water bodies. Surface water features within the extent of the contaminated groundwater plume on-Site and off-Site are regularly monitored. Site COCs have not been detected in surface water, eliminating groundwater discharge to surface water as a transport process and environmental media of concern. The groundwater plume associated with the Site does not extend to the Arkansas River to the west of the Site. This transport pathway is not considered complete.
- **Vapor Intrusion** – VOCs dissolved in groundwater (and/or sorbed to soil) beneath on-Site and off-Site buildings can partition to the soil-vapor as commonly described by equilibrium partition coefficients. Soil-vapor containing COCs may migrate from near the groundwater table (or soil source areas) through vadose zone soils and accumulate beneath basements or the slab of buildings and surrounding paved surfaces. The presence of fine-grained materials (silt and clay) in the vadose zone in the Site area may inhibit the upward migration of soil-vapor. If present, vapor beneath basements or building slabs may infiltrate through cracks in the foundation/slab or migrate along utility corridors or other preferential pathways. Vapors infiltrating buildings may then accumulate in enclosed spaces.

2.6.2.3 Point(s) of Exposure, Routes of Exposure and Receptor Populations

The point of exposure is the place where someone can come into contact with a substance present in the environment. Examples of points of exposure include private wells, exposed soil or work/living spaces exposed to intrusive vapors. The exposure route is the way a chemical comes in contact with a person (dermal contact, inhalation, or ingestion). The receptor population is a description of the individuals potentially exposed (child or adult resident, industrial/commercial worker, construction worker).

The points of exposure, exposure routes, and receptor populations associated with the environmental media potentially influenced by Site COCs (as identified above) include:

- **On-Site and Off-Site Excavations (Soil, Groundwater, Soil-Vapor)** – Adult construction workers performing excavation or utility work on-Site or off-Site may be exposed to Site COCs through the following exposure routes: dermal contact with soil and groundwater; inhalation of sub-slab soil-vapor and soil (dust); and ingestion of soil (dust).
- **Off-Site Lawn and Garden Wells** – As stated above, low concentrations of COCs have been detected in the vicinity of residences (single family and trailer homes) to the west of the Site. Private wells in these residential areas are currently used for lawn and garden watering purposes. Adult and children residents may have dermal contact with groundwater extracted from these wells.
- **Off-Site Indoor Air** – Low concentrations of COCs have been detected in the vicinity of residences (single family and trailer homes) to the west of the Site. Adult and children residents in these areas may be exposed to COCs in indoor air associated with the vapor intrusion pathway identified above.
- **On-Site Indoor Air** – The Site, and adjacent commercial/industrial areas owned by Spirit, are regulated by OSHA and therefore the inhalation pathway (from potential vapor intrusion) for adult commercial/industrial workers is not part of this evaluation. Boeing

has performed sub-slab soil-vapor sampling beneath Plant 2 and COCs detected in sub-slab soil-vapor were beneath OSHA worker exposure limits. This exposure route is not considered complete.

2.6.2.4 ARARs Evaluation

Development of remedial action objectives also requires careful consideration of ARARs, including the basis for waiver of ARARs under CERCLA and the NCP. "Applicable" and "relevant and appropriate" requirements (ARARs) are defined as follows:

1. Applicable requirements are those cleanup standards, standards of control and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal and State law that specifically address a hazardous substance, pollutant or contaminant, remedial action, location, or other circumstances at a CERCLA site.
2. Relevant and appropriate requirements are those cleanup standards, standards of control and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or State Law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.

A summary of ARARs is presented in Table 2. The ARARs are based on the complete exposure pathways identified above as well as the potential remedial alternatives described below. The primary ARARs which serve as a basis of the PRGs for the Site are the KDHE Tier 2 Risk-Based cleanup values (KDHE Tier 2 cleanup values) listed in the KDHE "Risk-Based Standards for Kansas, RSK Manual – 4th Version," June 2007 (KDHE RSK Manual) (KDHE, 2007). Alternate residential and non-residential clean-up levels for contaminants of concern emanating from the Boeing facility were described in a KDHE letter to Boeing dated May 7, 1999 (KDHE, 1999c) were also considered during the development of the RAOs.

2.6.3 Identification of Site-Specific Remedial Action Objectives

The 1988 EPA Guidance identifies four factors that should be evaluated when developing RAOs. The discussion of each factor in relation to the identification of Site-specific RAOs is included below:

1. "Whether the remediation goals for all carcinogens of concern, including those with goals set at the chemical-specific ARAR level, provides protection within the risk range of 10^{-4} to 10^{-7}";
   - This objective is achieved by using the KDHE Tier 2 cleanup values. The KDHE values for carcinogens are based upon a 1×10^{-5} risk level.
2. "Whether the remediation goals set for all noncarcinogens of concern, including those with goals set at the chemical-specific ARAR level, are sufficiently protective at the site";
   - This objective is achieved by using the KDHE Tier 2 cleanup values. The KDHE values and methodologies are consistent with federal guidelines. The KDHE RSK Manual states "KDHE believes that proper employment of this manual will result in risk-based remediation that is consistent with federally promulgated standards, including the Safe Drinking Water Act, and is protective of human health as defined by the National Contingency Plan (NCP)." (KDHE, 2007).

3. "Whether environmental effects (in addition to human health effects) are adequately addressed";
   - This objective is achieved by preventing further off-Site migration of groundwater exceeding KDHE Tier 2 standards and by reducing on-Site and off-Site concentrations of COCs in groundwater and soil, where applicable and reasonable.
4. "Whether the exposure analysis conducted as part of the risk assessment adequately addresses each significant pathway of human exposure identified in the baseline risk assessment."
   - The complete exposure pathways were qualitatively evaluated during the RAO development process. The use of the Tier 2 cleanup values identified in the KDHE RSK Manual provides risk-based PRGs which, when used with RAOs that reduce exposure, adequately address each significant pathway of human exposure.

Based on the identification of the complete exposure pathways above and evaluation of the factors identified by the 1988 EPA Guidance, the following is a list of the RAOs for Human Health for the Site:

- **On-Site and Off-Site Excavations**
  - Construction worker dermal contact with soil, and inhalation and ingestion of soil (dust):
    - Reduce construction worker exposure; and/or
    - Reduce contaminant levels in soil to KDHE Tier 2 non-residential soil pathway cleanup values.
  - Construction worker dermal contact with groundwater:
    - Reduce construction worker exposure; and/or
    - Reduce contaminant levels in groundwater to KDHE-approved alternate non-residential groundwater values, where available, or to KDHE Tier 2 non-residential groundwater cleanup values.
  - Construction worker inhalation of sub-slab soil vapor from contaminated soil and groundwater:
    - Reduce construction worker exposure; and/or
    - Reduce contaminant levels in soil and groundwater so that soil vapors do not exceed OSHA worker exposure limits.
- **Off-Site Lawn and Garden Wells**
  - Residential dermal contact with groundwater:
    - Reduce contaminant levels in off-Site groundwater to KDHE-approved alternate residential groundwater cleanup values, where available, or to KDHE Tier 2 residential groundwater cleanup values; and
    - Prevent migration of contaminants from on-Site soil that would result in ground water contamination in excess of KDHE-approved alternate residential groundwater values, where available, or to KDHE Tier 2 residential groundwater cleanup values.

- **Off-Site Indoor Air**
  - Residential inhalation of sub-slab soil vapor from contaminated groundwater:
    - Reduce contaminant levels in groundwater to KDHE-approved alternate residential groundwater cleanup values, where available, or to KDHE Tier 2 residential groundwater cleanup values; and
    - Prevent migration of contaminants from on-Site soil that would result in ground water contamination in excess of KDHE-approved alternate residential groundwater values, where available, or to KDHE Tier 2 residential groundwater cleanup values.

The RAOs for the protection of the environment are:

- **On-Site Soil**
  - Prevent migration of contaminants from soil that would result in ground water contamination in excess of KDHE-approved alternate non-residential groundwater values, where available, or to KDHE Tier 2 non-residential groundwater cleanup values.
- **On-Site Groundwater**
  - Reduce contaminant levels in groundwater to KDHE-approved alternate non-residential groundwater values, where available, or to KDHE Tier 2 non-residential groundwater cleanup values.
- **Off-Site Groundwater**
  - Reduce contaminant levels in groundwater to KDHE-approved alternate residential groundwater cleanup values, where available, or to KDHE Tier 2 residential groundwater cleanup values.

Restoration of groundwater quality is the key remedial action objective. The RAOs for the Site therefore focus upon the mitigation of groundwater contamination at and downgradient of the Site so as to comply with groundwater ARARs. Ongoing in situ treatment of source areas will contribute to achieving the RAOs and should be maintained. To minimize construction worker exposure, Boeing has established a procedure (which has been in place for over 20 years) for all excavation work on-Site. All excavations in areas of known soil or groundwater contamination are done in cooperation with Boeing environmental staff. If evidence of contamination is encountered during any excavation (visual or odors), the excavation must stop until additional assessment can be performed.

3.0 DESCRIPTION OF ALTERNATIVES

Numerous remedial technologies were considered based on their potential effectiveness to satisfy the RAOs described above. Potentially applicable remedial technologies screened in relation to special considerations for the Site, effectiveness for organics in the saturated and unsaturated zones, effectiveness for metals in the saturated zone, implementability, and cost. The process of evaluating the technologies by themselves and in combination with each other allowed for appropriate remedial alternatives to be developed. Table 3 presents a summary of the technology screening results.

Based on the results of the technology screening, three remedial alternatives were selected for further consideration in this RFS with the no action alternative. These alternatives and the key components of each alternative are summarized below and described in detail in the following sections.

3.1 Description of No Action (Alternative 1)

This alternative includes No Action. This alternative does not include continuation of existing IRMs or long term monitoring.

3.2 Description of Groundwater Extraction and Treatment (Alternative 2)

This alternative includes continuation of the current groundwater extraction and treatment system at the Site. The current system includes groundwater extraction and treatment, with dual phase treatment at select wells near source areas across the Site. A recent evaluation of the effectiveness of the treatment system indicated that the groundwater extraction system provides for capture throughout the majority of the Site; however, contingency measures may include installation of additional wells if future monitoring indicates this is necessary. This alternative includes continuation of the existing groundwater monitoring program, in addition to implementation of the recently approved Optimization Work Plan for the groundwater extraction system (Golder, 2009). Institutional controls would restrict groundwater use until aquifer restoration is complete. In addition, excavation of contaminated soil may be completed on an opportunistic basis if operational activities at the active facility allow future access to known source areas.

3.3 Description of Groundwater Extraction and Treatment with Nanoscale Zero Valent Iron (NZVI) Injection (Alternative 3)

This alternative includes continuation of the current groundwater extraction and treatment system (in addition to dual phase extraction within select areas) at the Site. The groundwater extraction and treatment system would be used in concert with injection of Nanoscale Zero Valent Iron (NZVI) within source areas. The groundwater extraction and treatment system would continue to provide capture of contaminated groundwater to mitigate off-site transport, while injection of NZVI would provide source treatment to reduce the overall time frame of the remedy.

Injection of NZVI would be targeted toward source areas; however, it is recognized that the distribution of the NZVI particles may be limited and the ability to install additional injection wells may be restricted by operational activities and/or infrastructure at the facility. Therefore, operation of the groundwater extraction system would likely be necessary for an extended period. Institutional controls would restrict groundwater use until aquifer restoration is complete. Contingency measures may include installation of additional groundwater extraction wells and/or continued operation of the groundwater extraction and treatment system if future monitoring indicates this is necessary. As described above, excavation of contaminated soil may be completed on an opportunistic basis if operational activities at the active facility allow access to known source areas in the future.

3.4 Description of Groundwater Extraction and Treatment with In Situ Bioremediation, Permeable Reactive Barrier (PRB) Walls and Monitored Natural Attenuation (MNA) (Alternative 4)

This alternative includes the following remedial elements:

- Continued use of existing Groundwater Extraction and Treatment system to mitigate off-Site transport of groundwater. This includes continued use of dual phase extraction in select wells to address contamination in vadose zone soils;
- In Situ Bioremediation within source areas to provide source treatment and reduce the time frame of the remedy. This technology has been demonstrated to be effective in providing for source treatment through pilot testing previously conducted at the Site;
- Installation of Permeable Reactive Barrier (PRB) walls using ZVI to provide for treatment of groundwater. This technology may be implemented in select locations to provide for plume management where lower concentrations of contaminants in groundwater have reduced the efficiency of the groundwater extraction and treatment system;
- Transition to Monitored Natural Attenuation (MNA) over time for management of residual plume constituents. This technology has been demonstrated, through extensive studies, to be effective in protecting human health and the environment;
- Institutional Controls that will restrict groundwater use until aquifer restoration is complete; and,
- Contingency measures to further ensure protection, if needed.

This alternative also provides for continued mitigation of off-Site transport of contaminants in groundwater through continued use of the groundwater extraction and treatment system. However, this alternative provides a framework to reduce the time frame of the remedy through source treatment. The source treatment activities may allow the transition to PRB walls and/or MNA as conditions allow; this would thereby reduce reliance on the groundwater extraction and treatment system, which will become less efficient as concentrations of constituents in groundwater continue to decrease over time. Groundwater monitoring would continue in order to demonstrate the effectiveness of source treatment activities and PRB walls. MNA is provided as a provisional remedy in the event that contaminant concentrations reach levels where natural attenuation processes provide for adequate management of groundwater within discrete areas of the Site. Contingency measures may include continuation of the groundwater extraction and treatment system, if monitoring indicates that in situ bioremediation and/or PRB walls are not effective in reducing concentrations of contaminants in groundwater. In addition, installation of additional groundwater extraction wells may be appropriate if future monitoring indicates this is necessary. As described above, excavation of contaminated soil may be completed on an opportunistic basis if operational activities at the active facility allow access to known source areas in the future.

4.0 EVALUATION OF REMEDIAL ALTERNATIVES

4.1 Criteria for Detailed Evaluation

In conformance with the NCP and the KDHE guidance, the following nine criteria were used to perform the detailed analysis for the four remedial alternatives:

1. Overall protection of human health and the environment;
2. Compliance with ARARs;
3. Long-term effectiveness and permanence;
4. Reduction of toxicity, mobility, or volume through treatment;
5. Short-term effectiveness;
6. Implementability;
7. Cost;
8. State Acceptance; and
9. Community acceptance.

Threshold criteria are those which must be met in order for a remedy to be eligible for selection and include (i) overall protection of human health and the environment and (ii) compliance with ARARs. Primary balancing criteria are used to weight the alternatives in order to determine the best selection for the site. The five primary balancing criteria are (i) long-term effectiveness and permanence; (ii) reduction of toxicity, mobility, or volume through treatment; (iii) short-term effectiveness; (iv) implementability; and (v) cost. Modifying criteria include State and Community acceptance. It is a statutory requirement that State and Community acceptance be considered in the remedial action selection process. An accurate representation of Community acceptance will be identified during the public comment period.

4.2 Individual Analysis of Remedial Alternatives

A general description of the nine criterion used to evaluate each remedial alternative is described below. The details for the evaluation of each individual remedial alternative using the nine NCP criteria is presented in Table 4. Alternative 1 (No Action) did not meet the threshold criteria; therefore, this alternative was included in the additional analyses provided in the comparative analysis sections below for comparative purposes only.

4.2.1 Overall Protection of Human Health and the Environment

The criterion for overall protection of human and the environment ensures that the risks for each pathway are eliminated, reduced, or controlled and includes consideration of whether an alternative poses any unacceptable short-term or cross-media impacts.

4.2.2 Compliance with ARARs

This criterion is used to ensure that the remedial alternative will meet the Federal, State, and local ARARs that have been identified for the Site. If an ARAR is not met, the basis for justifying one of the six waivers allowed under CERCLA should be discussed if the alternative is still being considered.

4.2.3 Long-term Effectiveness and Permanence

The long-term effectiveness and permanence of an alternative addresses the risk to the Site after the remedial action is complete. This includes the magnitude of residual risk (untreated areas or treatment residuals) and the adequacy and reliability of controls to manage this risk (containment systems and institutional controls).

4.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

This criterion focuses on the what the treatment processes are, what they treat, the amount they treat, the degree to which treatment is achieved and is irreversible, they type and quantity of treatment residuals, and whether the alternative addresses the principal threats. The reduction of toxicity, mobility, or volume through treatment criterion is first evaluated during the technology screening. In addition to the evaluation included in Table 4, details for the selected alternatives are included in Table 3 and Section 3.

4.2.5 Short-term Effectiveness

The short-term effectiveness criterion addresses the effects of the alternative during the construction and implementation phase until remediation goals have been achieved. This includes protection of the community during remediation, protection of workers during remediation, impacts to the environment from construction and implementation, time until remediation goals are achieved.

4.2.6 Implementability

The implementability criterion addresses technical feasibility, administrative feasibility, and availability of services and materials. Technical feasibility includes considerations for construction and operation, reliability of technology, ease of undertaking additional remedial action, and monitoring considerations. Administrative feasibility includes consideration of activities needed to coordinate with other agencies and offices, and the availability of services and materials addresses on-Site and off-Site treatment, storage, capacity, and disposal services, availability of necessary equipment and specialists, and availability of services and materials. Implementability is shown in part by previous pilot studies at the Site.

4.2.7 Cost

Cost considerations include total remedy costs (both capital costs and annual operation, maintenance and monitoring costs). Some types of capital costs that may be applicable include remedy design and remedy construction costs, equipment costs, land and Site-development costs, building and services costs, disposal costs, engineering oversight, license or permit costs, startup costs, and contingency costs. Annual operation, maintenance and monitoring costs may include labor, maintenance materials, energy, disposal of residues, services (such as analytical laboratory costs), administrative costs, insurance and taxes, maintenance reserve and contingency funds, rehabilitation costs, and costs for periodic Site reviews. All cost estimates are net present value using a constant 2 percent discount rate over a thirty-year time frame.

4.2.8 State and Community Acceptance

State and community acceptance is required for any selected remedial option. This criterion should consider technical and administrative concerns of the State and concerns the public may have. State and Community acceptance will be addressed in more detail once comments on this RFS have been received.

4.3 Comparative Analysis of Remedial Alternatives

A summary of the comparative analysis of remedial alternatives is provided in Table 5. The comparative analysis for each of the NCP criterion is discussed below.

4.3.1 Overall Protection of Human Health and the Environment

Each of the alternatives except Alternative 1 provides adequate long-term protection of human health and the environment through the use of institutional controls until groundwater restoration is achieved. However, Alternative 2, involving groundwater extraction and treatment alone, is expected to require longer remedial timeframes so that the groundwater risk is extended. In addition, Alternative 3 is expected to have a longer remedial timeframe than Alternative 4 due to limitations on availability to source areas and distribution of NZVI particles through the existing well infrastructure.

4.3.2 Compliance with ARARs

Each alternative except Alternative 1 is expected to eventually comply with groundwater ARARs. However, Alternative 2, which involves groundwater extraction and treatment alone, will require the greatest time for compliance, and Alternative 4 will likely achieve compliance in the shortest time. As discussed above, the time required to comply with groundwater ARARs will be dependent, to some extent, on access to source areas at the operational facility. However, due to the installation of PRB walls in Alternative 4, plume treatment may be achieved even in areas where source treatment is not achievable due to infrastructure limitations in the short term.

4.3.3 Long-term Effectiveness and Permanence

With the exception of Alternative 1, all of the alternatives satisfy the statutory preference for treatment and the treatment processes employed are permanent treatment technologies. However, the long-term effectiveness of Alternative 2 is a concern as the groundwater extraction and treatment system might not be able to achieve the long-term groundwater restoration goals in a reasonable timeframe. Alternatives that utilize source treatment, PRB walls and/or MNA (Alternatives 3 and 4) are expected to have higher mass removal rates and thus achieve groundwater restoration goals in a shorter time-frame than groundwater extraction and treatment alone (Alternative 2). Alternative 4, which supplements the groundwater extraction and treatment system with source treatment, plume treatment and MNA is expected to have the highest mass removal rates and achieve restoration goals in the shortest time-frame.

4.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

With the exception of Alternative 1, all of the alternatives will reduce the toxicity, mobility and volume of contaminants at the Site and would each generate some secondary wastes in association with the groundwater extraction and treatment components. Alternatives 3 and 4 are expected to have the highest degree of reduction of toxicity, mobility, and volume because they have components (ZVI for alternative 3 and in situ bioremediation for alternative 4) that will destroy chlorinated solvents and reduce chromium in groundwater with no byproducts requiring disposal.

4.3.5 Short-term Effectiveness

Alternatives 3 and 4 will result in the greatest adverse impact to the community and local ecology as a result of the well installation activities and construction of PRB walls; however, these impacts are expected to be relatively minimal. Alternatives 1 and 2 have the least adverse short-term impact because they include application of fewer technologies and in general require less activity.

4.3.6 Implementability

Alternatives 3 and 4 are also the most difficult to implement because they include several technologies in combination. Alternatives 1 (no action) and 2 (groundwater extraction and treatment alone) are the easiest to implement. In general, contractors, vendors, and materials are readily available for all of the alternatives and no issues are expected with administrative coordination.

4.3.7 Cost

Alternative 1 is the most cost effective alternative, followed (in order of increasing cost) by Alternatives 4, 3, and 2, respectively. The estimated cost for Alternative 2 includes operation of the full groundwater extraction and treatment system for 30 years. Alternatives 3 and 4 include continued use of the groundwater extraction and treatment system over this period; however, the cost estimates for these alternatives assume that the treatment system would be limited over time as focused in situ source treatment activities reduce the footprint (i.e. aerial size) of the groundwater plume. The cost estimates for these alternatives include continued operation of the full scale groundwater extraction and treatment system for 5 years (during which time source treatment activities would be implemented), with reductions in operation and monitoring costs in years 5 through 15, and further reductions (to approximately 50 percent of the full scale system) in years 15 through 30.

4.3.8 State and Community Acceptance

Alternative 2 is also expected to have the state greatest potential for community acceptance due to the significantly lower short-term risks to the community.

4.4 Results of Comparative Analysis

In summary, Alternative 4 is equal or superior to all of the other alternatives in relation to the NCP criteria. Alternative 4 meets the threshold criteria, is the most effective long-term, reduces the toxicity and volume of groundwater contaminants in the shortest timeframe, has limited short-term adverse impacts to the local community, construction workers, and the local ecology, is relatively easy to implement and is the most cost-effective alternative (except for Alternative 1, which would not achieve RAOs).

5.0 RECOMMENDED REMEDIAL ALTERNATIVE

Alternative 4 was selected as the recommended corrective action for the Site as it involves integrating a selection of remedial elements (including groundwater extraction and treatment, in situ bioremediation, PRB walls and MNA) into a single remedial approach that will be protective of human health and the environment, while at the same time, accelerating the overall time frame to reach Site remediation goals.

The existing groundwater extraction and treatment system has been effective in achieving groundwater capture to minimize off-Site migration of contaminants and reduce the overall mass of contaminants on-Site. This system will continue to be an integral element of the recommended corrective actions for the Site. However, the effectiveness of the groundwater extraction and treatment system in achieving mass reduction of contaminants in groundwater over time has rendered the system less efficient, as substantial volumes of groundwater extracted yield decreasing concentrations of contaminants. Elements of the in situ treatment program will be implemented at the Site in a phased manner, with continued reliance on the groundwater extraction and treatment system to maintain capture of the groundwater plume. The remedial strategy is designed to accelerate overall restoration time, achieved through the combined effects of the in situ treatment of source areas using accelerated bioremediation and management of downgradient plume areas through PRB walls. This approach will allow for decreased reliance on the groundwater extraction and treatment system over time, and may ultimately facilitate transition of areas of the Site to MNA if performance monitoring demonstrates this technology may be feasible at that time. At this time, MNA is provided as a provisional component of the remedial approach and a monitoring program (consistent with KDHE guidance) would be implemented to provide a demonstration of feasibility prior to consideration of MNA at specific areas of the Site.

A summary of proposed remedial activities at various areas of the Site is presented in Table 1. The in situ bioremediation and PRB wall remedial actions proposed are based on the current understanding of Site conditions. It is recognized that current operational activities at the facility may limit access and restrict remedial activities. Therefore, source treatment activities will progress on an opportunistic basis as permitted by operational activities at the Site. We anticipate that the groundwater extraction and treatment system will continue to be a central element of the recommended corrective actions for the Site for an extended period. However, a central goal of the remedial approach is to evaluate the effectiveness of the treatment system within each sub area on an annual basis, and transition individual sub areas to in situ treatment programs, PRB walls and/or MNA programs when feasible. Therefore, the design and implementation of in situ treatments is important to achieve continued mass removal of chlorinated VOCs in groundwater. Implementation of the prospective in situ remedial elements may involve consideration of: (1) Site hydrogeologic and geochemical conditions that appear favorable for in situ biodegradation of organic constituents and/or transformation of hexavalent chromium, (2) application of chemical reactants (e.g., zero valent iron) for passive treatment using permeable reactive barriers, and (3) revising the local area existing groundwater extraction and treatment remedial system so that the approach is compatible with the hydrodynamic characteristics of the source area.

We anticipate implementation of the proposed corrective actions following approval of the CAD for the Site. The prospective corrective actions may be implemented over time to enhance source treatment and/or plume management and transition toward the Site exit strategy. We propose submittal of an Addendum to this report on an annual basis to inform KDHE of the status of the proposed and prospective corrective actions for each of the sub areas at the Site.

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TABLES

TABLE 1
SUMMARY OF INTERIM REMEDIAL MEASURES AND PROPOSED CORRECTIVE ACTIONS
FORMER BOEING WICHITA FACILITY
WICHITA, KANSAS

Sub-Area	Primary COCs	Interim Remedial Measures	Proposed Corrective Action	Prospective Corrective Action
South Campus Area	Chlorinated ethenes Hexavalent chromium	Groundwater extraction and treatment Soil excavation and disposal Soil vapor extraction	Groundwater extraction and treatment Soil vapor extraction	Permeable reactive barrier Monitored natural attenuation
Plant 2	Chlorinated ethenes Chlorinated methanes Petroleum hydrocarbons Hexavalent chromium	Groundwater extraction and treatment Soil excavation and disposal Soil vapor extraction In situ bioremediation (Plant 2 vicinity) Zero valent iron injection (Englewood vicinity)	Groundwater extraction and treatment Soil vapor extraction In situ bioremediation	Permeable reactive barrier Monitored natural attenuation
Reclamation Area	Chlorinated ethenes Chlorinated methanes Petroleum hydrocarbons Hexavalent chromium	Groundwater extraction and treatment Soil excavation and disposal Soil vapor extraction	Groundwater extraction and treatment Soil vapor extraction In situ bioremediation	Permeable reactive barrier Monitored natural attenuation
Plant 1 Area	Chlorinated ethenes Chlorinated methanes Hexavalent chromium	Groundwater extraction and treatment Soil vapor extraction	Groundwater extraction and treatment Soil vapor extraction	Permeable reactive barrier In situ bioremediation Monitored natural attenuation
500 Ramp Area	Chlorinated ethenes Petroleum hydrocarbons	Groundwater extraction and treatment Soil vapor extraction In situ bioremediation	Groundwater extraction and treatment Soil vapor extraction In situ bioremediation	Permeable reactive barrier Monitored natural attenuation
MAFB/Hangar 118F Area	Chlorinated ethenes Chlorinated methanes	None to date	None to date	None to date

Prepared by: ____________

Checked by: ____________

Reviewed by: ____________

TABLE 2
IDENTIFICATION OF ARARs
FORMER BOEING WICHITA FACILITY

Type	Scope	Citation	Description	Overview of Reqirements	Primary Basis for Determination	Determination of Applicable/Relevant and Appropriate
Chemical	Federal	40 CFR Part 129 (CWA - 33USC §§ 1251-1376)	Toxic Pollutant Effluent Standards	This part establishes surface water effluent standards for the following toxic pollutants: aldrin/dieldrin, DDT, DDE, DDD, endrin, toxaphene, benzidine, and PCBs.	These toxic pollutants were not identified as COC's	No/No
Chemical	Federal	40 CFR Section 131.36 (CWA - 33 USC §§ 1251- 1376)	Surface Water Quality Criteria for Priority Toxic Pollutants	This section establishes freshwater ambient water quality standards for 126 priority pollutants, including metals, VOCs, SVOCs, PAHs, pesticides, PCBs, and dioxins. This section only applies to those states not in compliance with the Clean Water Act Section 303(c)(2)(B).	There are no impacts to surface water on the Site proper.	No/No
Chemical	Federal	40 CFR Part 141 (SDWA - 42 USC § 300)	National Primary Drinking Water Standards	This part specifies maximum contaminant levels (MCLs) and MCL Goals (MCLGs), which are used as drinking water standards for public water systems. MCLs are specified for a wide range of organic and inorganic analytes. Of particular note are MCLs for PCE (5 ug/L), TCE (5 ug/L), cis-1,2-DCE (70 ug/L), vinyl chloride (2 ug/L), and benzene (5 ug/L).	Groundwater is not a current source of drinking water; accordingly, drinking water standards are not applicable. However, contaminated groundwater is a potential source of drinking water and has the potential to migrate to a current source of drinking water.	No/Yes
Chemical	Federal	40 CFR Part 143 (SDWA - 42 USC § 300)	National Primary Drinking Water Standards	This part specifies secondary maximum contaminant levels (MCLs) for public water systems. These regulations control contaminants in drinking water that primarily affect the aesthetic qualities relating to the public acceptance of drinking water (e.g. , total dissolved solids, iron, manganese, pH).	Site groundwater is not a current source of drinking water; accordingly, drinking water standards are not applicable. Secondary MCLs address aesthetic qualities and are not risk-based. Accordingly, these standards are not considered relevant and appropriate.	No/No
Chemical	State	KAR Title 28, Article 15	Kansas Drinking Water Standards	Establish maximum contaminant levels (MCLs) for Kansas. The federal MCLs specified in 40 CFR 141 are generally adopted by reference, including those for organic contaminants.	Groundwater is not a current source of drinking water; accordingly, drinking water standards are not applicable. However, contminated groundwater is a potential source of drinking water and has the potential to migrate to a current source of drinking water. Accordingly, MCLs are considered relevant and appropriate.	No/Yes
Chemical	State	KAR § 28-16-28	Kansas Surface Water Quality Criteria	Provide surface water quality standards, surface water quality anitdegration policy, surface water classification and use policy, and surface water quality criteria.	The Site proper does not have known impacts to surface water.	No/No
Chemical	State	Risk-Based Standards for Kansas RSK Manual - 4th Version, June 2007	Kansas Risk-Based Standards	Describes process for establishing chemical-specfic and site-specfic cleanup goals for soil and groundwater that are protective of human health and the environment.	These risk-based standards have been widely used at the Site proper during this investigation. No formal risk assessment was developed that provides an established calculation methodology specific to this Site. Accordingly, this manual provides the most appropriate framework under which to calculate risk-based standards.	TBC
Location	Federal	40 CFR § 6.302(a) and Apppendix A (Protection of Wetlands) EO No. 11,990	Actions Taken in a Wetland	This part requires that federal agencies avoid the destruction or loss of wetlands.	There are no known wetlands on the Site proper.	No/No
Location	Federal	40 CFR § 6.302(e) (Wild and Scenic Rivers Act - 16 USC ? 1271)	Wild and Scenic Rivers Impact	This regulation establishes certain requirements applicable to water resources projects in the National Wild and Scenic Rivers System.	The Site proper does not contain any rivers designated as "wild and scenic rivers."	No/No

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Location	Federal	50 CFR Part 17; 50 CFR Part 222; 50 CFR Part 402 (Endangered Species Act - 16 USC § 1531)	Endangered Species Conservation	These regulations requires certain actions to protect endangered species within critical habitats are located in the area. Relevant and appropriate if habitat is suitable for endangered species habitat.	The Site proper has not been identified as habitat for any endangered species.	No/No
Location	Federal	50 CFR Part 27(National Wildlife Refuge System - 16 USC § 685)	Wildlife Refuges Impact	This regulation restricts activities within a National Wildlife Refuge area.	The Site proper has not been identified as a Wildlife Refuge.	No/No
Location	Federal	50 CFR § 35.1 (Wilderness Act - 16 USC §§ 1311-1316)	Wilderness Area Impact	This section establishes the National Wilderness Preservation System in order to preserve wilderness areas.	The Site proper does not have any designated wilderness areas.	No/No
Location	Federal	32 CFR Part 229; 40 CFR § 6.301(b); 36 CFR Part 800 (Nat's Hist. Preser. Act)	Historic Location Consideration	These regulations require federal agencies to account for any effect of any federally-assisted undertaking of licensing of any district, building, structure, or object included in the National Register of Historical Places.	Accordingly to the National Register Information System published online by the National Park Service, the Site proper does not contain items included in the National Register of Historical Places. This database can be accessed at http://www.nr.nps.gov/.	No/No
Location	Federal	13 USC § 1700 (Federal Land Policy and Management Act - 13 USC § 1700)	Federal Land Management	These requirements relate to the use of public lands (e.g. rights-of-way regulation, land use planning, and land acquistion and appropriation of waters on public lands). According to the Federal Land Policy and Management Act, the term "public lands" describes any land and interest in land owned by the United States within several States and administered by the Secretary of he Interior through the Bureau of Land Management.	The Site proper is nor a federal land, nor a public land administered by the Bureau of Land Management.	No/No
Location	Federal	16 USC §§ 1451-1464	Coastal Zone Management	This guideline prohibits federal agencies from takng activities not in agreement with the state's approved coastal zone management program.	The Site proper does not have any Coastal Zones.	No/No
Location	Federal	Executive Order (EO) No. 11,988	Actions Taken in a 100-Year Floodplain	The Excutive Order requires federal agencies to evaluate the effects of actions taken in a 100-year floodplain in order to avoid impacts.	The Site Proper does not have any 100-yr floodplains.	No/No
Location	Federal	40 CFR § 6.301(a) (Historic Sites, Building, and Antiquities Act - 16 USC § 461 467	Natural Landmarks Consideration	This section requires federal agencies to consider natural landmarks in the National Registry of Natural Landmarks.	According to the National Landmark Guide published online by the National Park Service, the Site proper does not contain items included in the National Registry of Natural Landmarks.	No/No
Location	Federal	40 CFR § 6.301(c) (Archeological & Historical Preservation Act - 16 USC § 469)	Historical and Archeological Data Preservation	This guideline provides procedures for preserving historical and archeological data that might be destroyed by altering the location in a federal construction project, licensed activity, or program.	There are no known historical or archeological artifacts at the Site proper.	No/No
Location	State	KAR § 118-3	Kansas Historic Preservation Act	Establishes framework under which the State Historic Preservation Office (SHPO) identifies historic preservation sies. A 1988 amendment further defined the "environs" of historic properties, requiring that the SHPO receive notice of any proposed project within 500 feet of a listed historic property located within the corporate limits of a city or within 1000 feet of a listed historic property located in the unincorporated portion of a county.	There are no known historical or archeological artifacts at the Site proper.	No/No

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Type	Scope	Citation	Description	Overview of Reqirements	Primary Basis for Determination	Determination of Applicable/Relevant and Appropriate
Action	Federal	40 CFR Part 61, Subpart M (CAA, 42 USC § 7401)	Federal National Emission Standards for Asbestos	Establishes standards for the demolition and renovation of structures having asbestos-containing material (ACM) and the ultimate disposal of ACM.	No remedial alternatives include demolition or renovation of buildings containing ACM.	No/No
Action	Federal	40 CFR Part 63, Subpart GGGGG (Sections 63.7880 - 63.7957) (CAA, 42 USC § 7401)	Federal National Emission Standards for Hazardous Air Pollutants	Establishes national emissions limitations and work practive standards for hazardous air pollutants (HAP) emitted from site remediation activities.	This subpart is not applicable to site remediation performed under CERCLA as a remedial action or a nontime-critical removal action [40 CFR 6.7881(b)(2)], and is only potentially applicable to site remediation performed at a facility that is a major source of HAPs. Site is exempt from remediation NESHAP under the less than 1 megagrem per year exemption. Emissions are tracked monthly at the site to assure the site meets the exemption rule.	No/No
Action	Federal	40 CFR Part 63 Subpart VV (Sections 63.1040-63.1050) (CAA, 42 USC § 7401)	National Emmission Standards for Oil-Water Separators and Organic-Water Separators	The provisions of this subpart apply to the control of air emmissions from oil-water separators and organic-water separators for hazardous air pollutants and other regulated compounds, including benzene, trichloroethylene, and vinyl chloride.	Remedial alternatives include the use air strippers. Total amount of contaminants emited from air strippers is calculated monthly.	Yes/Yes
Action	Federal	40 CFR Part 122 (CWA - 33 USC §§ 1251-1376)	National Pollutant Discharge Elimination System Requirements	Establishes requirements for permits to authorize the point source discharge of pollutants into waters of the United States, including stormwater discharges associated with construction activities equal to or greater than 1 acre [40 CFR 122.26(b)(15)]. These requirements primarily address best management practices for erosion and sediment control.	Water discharged from air strippers at the Site flows to Industrial Waste Treatment Plant or to outfalls per Kansas Water Pollution Control Permit No. I-AR94-PO46.	Yes/Yes
Action	Federal	40 CFR Parts 144-147 (SDWA 42 USC § 300)	Underground Injection Control (UIC) Standards	Establishes regulations for subsurface injections. Regulations are designed to provide for protection of groundwater used for drinking water. Class I - IV wells address injections related to hazardous waste disposal and recovery of oil, natural gas, and mining products. Class V wells address injections not addressed by Class I - IV. Class V wells do not require a permit unless the Class V well may cause a violation of drinking water regulations or for other specfic circumstance (40 CFR 144.84).	Injection of electron donor material as part of reductive dechlorination would be considered a Class V well, and subject to applicable portions of this regulatory part. However, no permit is required for these injection wells, and notification requirements (e.g., 40 CFR 144.83) are administrative and therefore are not ARARs.	No/Yes
Action	Federal	40 CFR Parts 230-231 and 33 CFR Part 323 (CWA - 33 USC §§ 1251-1376)	Dredge or Fill Requirements	Establishes requirements for permits to authorize the discharge of dredged or fill material into navigable waters.	No remedial alternatives include the discharge of dredged or fill material into navigable waters.	No/No
Action	Federal	40 CFR Parts 260-265, 268 (Solid Waste Disposal Act - 42 USC §§ 6901-6987)	Federal RCRA Hazardous Waste Management and Land Disposal Restrictions (LDR)	Establishes federal rules for identifying, generating, transporting, treating, storing, and disposing of harardous waste.	No remedial alternatives include the generation of hazardous waste, but in the event source material is encountered and could be removed, it will be characterized and disposed in accordance with appropriate regulations.	No/Yes
Action	Federal	40 CFR Part 403 (CWA - 33 USC §§ 1251-1376)	National Pretreatment Standards	Establishes standards for controlling pollutants which pass through or interfere with treatment processes in publicly owned treatment works (POTW) or which may contaminant sewage sludge.	No remedial alternatives include discharges to POTWs.	No/No

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Type	Scope	Citation	Description	Overview of Reqirements	Primary Basis for Determination	Determination of Applicable/Relevant and Appropriate
Action	Federal	49 CFR Parts 171-173	Department of Transporation Rules for Transporation of Hazardous Materials	Establishes requirements for transporation of hazardous materials, including container, placarding, etc.	Remedial alternatives have potential for transporation of hazardous materials. In the event source material is encountered and could be removed, it will be characterized and disposed in accordance with appropriate regulations.	No/Yes
Action	Federal	29 CFR Parts 1910 and 1926	Occupational Safety and Health Administration	Establishes requirements for occupational safety and health, including hardardous material storage requirements and training requirements for personnel working on hazardous waste sites.	Remedial alternatives include working on a hazardous waste site and the potential for storage of hazardous materials.	Yes/Yes
Action	State	KAR Title 28, Article 16	Water Pollution Control	Provide permitting framework and standards associated with discharges to surface water.	Water discharged from air strippers at the site flows to Industrial Waste Treatment Plant or to outfalls per Kansas Water Pollution Control Permit No. I-AR94-PO46.	Yes/Yes
Action	State	KAR Title 28, Article 19	Kansas Air Regulations	Provides ambient air quality standards and air pollution control standards.	Remedial actions have the potential to create an air emission source.	Yes/Yes
Action	State	KAR Title 28, Article 29	Kansas Solid Waste Management Regulations	Establishes regulations for solid waste collection, storage, transportation, and disposal. Includes regulations for composting and landfill operations.	Remedial alternativies include monitoring well installation and groundwater monitoring, which generate minor amounts of solid waste (e.g., disposable PPE, soil cuttings). Solid waste generated as part of alternatives are subject to these regulations.	Yes/Yes
Action	State	KAR Title 28, Article 30	Kansas Water Well Construction and Abandonment	Specifies requirements for construction and abandment of water wells, including monitoring wells.	Applicable for remedial action alternatives that propose to construct or abandon monitoring wells. All monitoring wells and recovery wells at the site have been constructed by licensed water well contractors.	Yes/Yes
Action	State	KAR Title 28, Article 31	Kansas Hazardous Waste Management Regulations	Establishes regulations for hazardous waste identification, storage, transportation, and disposal. Regulations include universal waste and used oil.	Remedial alternatives include monitoring well installation and groundwater monitoring, which generate minor amounts of solid waste (e.g., disposal PPE, soil cuttings). None of these waste are anticipated to be hazardous waste. In the event source material is encountered and could be removed, it will be characterized and disposed in accordance with appropriate regulations.	No/Yes
Action	State	KAR Title 28, Article 46	Kansas Underground Injection Control Program	Establishes regulations for subsurface injections. State regulations generally adopt federal regulations by reference.	Injection of electron donor material as part of reductive dechlorination would be considered a Class V well, and subject to applicable portions of this regulatory part. However, no permit is required for these injection wells, and notification requirement are administratve and therefore are not ARARs.	No/Yes
Action	State	KAR Title 28, Article 73	Environmental Use Controls (EUC) Program	Establishes a regulatory framework for the implementation of enforcable deed restrictions to be protective of human heath.	Some remedial alternatives include institutional controls that specify this program.	Yes/Yes
Action	State	KAR Title 66, Articles 6 through 14	Kansas Board of Technical Professions	Establishes code of conduct and licensing for Kansas professions, including geologists, engineers, and land surveyors.	At this Site, State representatives have not always requested that remedial investigations or pilot studies for remedial action be professionally sealed.	Yes/Yes
Action	State	KSA 82a-701 et seq	Kansas Water Appropriation Act	Establishes procedures for water use. A permit generally must be obtained for diversion of water for remediation.	Term permits have been issued by the Division of Water Resources for water withdrawal by the remedial systems at the Site.	Yes/Yes

TABLE 3
TECHNOLOGY SCREENING
FORMER BOEING FACILITY, WICHITA, KANSAS

Remedy Number	Technology	Description	Contaminants Treated	Specific Considerations for Boeing Site	Effectiveness for Organics in Unsaturated Zone	Effectiveness for Organics in Saturated Zone	Effectiveness for Metals in Saturated Zone	Average Score for Effectiveness	Implementability	Cost	Retained?
In-Situ Chemical Technologies - Source Destruction											
1	In-Situ Chemical Oxidation	Most organics are destroyed; however, hexavelent chromium would not be treated, and reduced chromium species may be oxidized to hexavalent chromium	Chlorinated Solvents, with few potential exceptions (TCA, Chloroform, CT, and DCA).	Will disrupt current anaerobic natural attenuation processes, may cause iron fouling of reagent delivery points and aquifer, would not treat and may mobilize hexavalent chromium.	Medium-Low	Medium	Low	Medium-Low	Medium	Medium-High	No
2	Nanoscale Zero-Valent Iron (ZVI)	Nanoscale and/or colloidal scale ZVI may be injected in aquifer. Organics are destroyed and hexavalent chromium is reduced to trivalent chromium.	Chlorinated Solvents and Hexavalent Chromium	Does not reliably address source above water table.	Low	Medium	Medium	Medium-Low	Medium-High	High	Not Alone
3	Iron Permeable Reactive Barrier (PRB)	Organics are destroyed by iron wall while hexavalent chromium is reduced to trivalent chromium.	Chlorinated Solvents and Hexavalent Chromium	Does not treat source, but restores downgradient groundwater and is cheaper than P&T.	N/A	Medium	Medium	Medium-Low	Medium-High	Medium-Low	Not Alone
In-Situ Biological Technologies - Source Destruction											
4	In Situ Bioremediation through Reductive Dechlorination - Nutrient Injection	Injection of nutrients to saturated zone to promote enhanced bioremediation, which is already occurring in many areas.	Chlorinated Solvents and Hexavalent Chromium	Does not reliably address source above water table.	Low	Medium-High	Medium	Medium	High	Low	Not Alone
Source Extraction Technologies											
5	SVE	Removes VOCs from unsaturated zone through extraction of soil vapor.	Chlorinated Solvents	Does not treat source below GW table, removal will be limited by rate of diffusion. Would not treat and may mobilize hexavalent chromium	Medium-High	N/A	N/A	Low	Medium-High	Medium	No
6	Nitrogen Sparging with SVE	Nitrogen sparging removes VOCs from GW while SVE removes COCs from vadose zone soil.	Chlorinated Solvents	Does not treat source below GW table. Would not treat hexavalent chromium	Medium-High	Medium-Low	Low	Medium	Medium-High	Medium	No

TABLE 3
TECHNOLOGY SCREENING
FORMER BOEING FACILITY, WICHITA, KANSAS

Remedy Number	Technology	Description	Contaminants Treated	Specific Considerations for Boeing Site	Effectiveness for Organics in Unsaturated Zone	Effectiveness for Organics in Saturated Zone	Effectiveness for Metals in Saturated Zone	Average Score for Effectiveness	Implementability	Cost	Retained?
7	Air Sparge with SVE	Air removes VOCs from groundwater, SVE removes VOCs from vadose zone soil.	Chlorinated Solvents	Will disrupt current anaerobic natural attenuation processes. Concern for iron fouling and channelized air flow. Would not treat and may mobilize hexavalent chromium	Medium-High	Medium-Low	Low	Medium	Medium-High	Medium	No
8	Thermal Remediation and SVE	Boils off contaminants which are collected and treated ex-situ. "Steam Cleans" contaminated portion of aquifer. Aquifer conditions become aerobic.	Chlorinated Solvents	Requires more detailed source characterization. Possible remobilization of DNAPL. Would not treat and may mobilize hexavalent chromium.	High	Medium-High	Low	Medium	Medium-Low	Very High	No
9	Dual-phase extraction (groundwater and SVE)	Component of Current Remedy	All	Remedy timeframe is indefinite. Limited by rate of diffusion.	Medium-High	Medium	Medium-High	Medium-High	Medium-Low	High	Not Alone
10	Groundwater Extraction and Treatment	Current Remedy	All	Does not address source in unsaturated zone, remedy timeframe is indefinite. Limited	N/A	Medium	Medium-High	Medium-Low	Medium-Low	High	Current Remedy for Comparison
11	Co-Solvent or surfactant Flushing (with Pump and Treat)	Solvent or surfactant is injected and groundwater is recovered in order to remove both dissolved phase organics and NAPL.	Chlorinated Solvents	Extensive capital costs, diffusion-limited transport from fine-grained lenses. Would not treat hexavalent chromium.	Low-Med	Medium	Low	Medium-Low	Medium-Low	Very High	No
Combination Technologies											
12	Groundwater Extraction and Treatment (with Dual Phase where necessary), with Nanoscale ZVI	Maintain existing dual-phase groundwater extraction system. Inject ZVI where practicable to achieve source treatment and minimize overall timeframe of P&T remedy	Chlorinated Solvents and Hexavalent Chromium	Does not address BTEX and inorganics in GW, very difficult to delver to smear zone. May increase toluene and arsenic concentrations.	Medium-High	Medium-High	Medium-High	Medium-High	Medium	High	Yes

TABLE 3
TECHNOLOGY SCREENING
FORMER BOEING FACILITY, WICHITA, KANSAS

Remedy Number	Technology	Description	Contaminants Treated	Specific Considerations for Boeing Site	Effectiveness for Organics in Unsaturated Zone	Effectiveness for Organics in Saturated Zone	Effectiveness for Metals in Saturated Zone	Average Score for Effectiveness	Implementability	Cost	Retained?
12	Groundwater Extraction and Treatment (with Dual Phase where necessary), with In Situ Bioremediation, PRB Walls and MNA	Maintain existing dual-phase groundwater extraction system. Inject nutrient to support bioremediation where practicable to achieve source treatment. Transition from P&T to PRB walls and MNA where practicable to minimize overall timeframe of P&T remedy	Chlorinated Solvents and Hexavalent Chromium	Does not address BTEX and inorganics in GW, very difficult to deliver to smear zone. May increase toluene and arsenic concentrations.	Medium-High	Medium-High	Medium-High	Medium-High	Medium	Medium-High	Yes
14	Recirculation wells and in-well nitrogen stripping and SVE	Removes VOCs in GW by air stripping using nitrogen. Would be combined with SVE.	Chlorinated Solvents	Would not treat hexavalent chromium. Need tight well spacing.	Medium	Medium-Low	N/A	Medium-Low	Medium-Low	Medium-High	No
15	Soil Mixing with In-Situ Chemical Oxidation	Use large auger to mix soil with chemical oxidant creating a zone of treatment for unsaturated zone and inject oxidant into saturated zone as described above.	Chlorinated Solvents	Requires more source delineation, will disrupt current natural attenuation processes. Would not treat and may mobilize hexavalent chromium. Will generate solid-waste for off-site disposal.	Med	Med-High	Low	Medium	Medium-Low	High	No

TABLE 4
ALTERNATIVE EVALUATION SUMMARY
FORMER BOEING WICHITA FACILITY

	PERFORMANCE			
EVALUATION CRITERIA	**NO ACTION (ALTERNATIVE 1)**	**GROUNDWATER EXTRACTION AND TREATMENT (ALTERNATIVE 2)**	**GROUNDWATER EXTRACTION AND TREATMENT WITH NANOSCALE ZVI (ALTERNATIVE 3)**	**GROUNDWATER EXTRACTION AND TREATMENT WITH IN SITU BIOREMEDIATION, PRB WALLS AND MNA (ALTERNATIVE 4)**
1. ***Overall Protection of Human Health and the Environment***	• The site currently has a dual phase extraction and treatment system in place to mitigate plume migration. The no action alternative would discontinue the use of this system and therefore would provide no protection against off site migration of the groundwater plume to potential downgradient receptors. • No institutional controls would be in place to provide protection. • This alternative would not adequately protect human health and the environment	• Institutional controls over groundwater would provide protection until groundwater restoration is achieved. • Groundwater restoration provided by groundwater extraction and treatment. • Performance groundwater monitoring and contingency measures will ensure protection. • Primary infrastructure is currently in place, so construction activities and associated disturbance would be minimal.	• Institutional controls over groundwater would provide protection until groundwater restoration is achieved. • Groundwater restoration provided by groundwater extraction and treatment, and the chemical destruction and natural attenuation of constituents in groundwater. • Treatment of source areas through NZVI injection would minimize remedy timeframe. • Performance groundwater monitoring and contingency measures will ensure protection. • Primary infrastructure for groundwater extraction and treatment system is currently in place, so construction activities and associated disturbance would be minimal.	• Institutional controls over groundwater would provide protection until groundwater restoration is achieved. • Groundwater restoration provided by groundwater extraction and treatment, biological and chemical destruction, and natural attenuation of constituents in groundwater. • Treatment of source areas through in situ bioremediation injection would minimize remedy timeframe. • Installation of PRB walls over time would provide protection of groundwater in areas where lower concentrations of contaminants render groundwater extraction and treatment less efficient. • Transition to MNA over time when source depletion has occurred to the extent where MNA becomes feasible. • Performance groundwater monitoring and contingency measures will ensure protection. • Primary infrastructure for groundwater extraction and treatment system is currently in place, so construction activities and associated disturbance would be minimal. Additional construction activities would be required for PRB wall installation.
2. ***Compliance with Federal and State ARARs***	• Not expected to achieve chemical-specific groundwater quality ARARs	• May eventually attain Federal and State chemical specific groundwater ARARs • Remedy timeframe is indefinite as groundwater treatment is limited by long term depletion of source areas.	• Expected to achieve chemical-specific groundwater quality ARARs through groundwater extraction and treatment, and chemical destruction of chlorinated solvents and chemical reduction of hexavalent chromium. However, many applications of NZVI for an extended period may be required.	• Expected to achieve chemical-specific groundwater quality ARARs through groundwater extraction and treatment, and biological and chemical destruction of chlorinated solvents and reduction of hexavalent chromium. Inclusion of MNA is based on demonstration of feasibility to achieve chemical-specific groundwater quality ARARs once site conditions become favorable.

TABLE 4
ALTERNATIVE EVALUATION SUMMARY
FORMER BOEING WICHITA FACILITY

EVALUATION CRITERIA	PERFORMANCE NO ACTION (ALTERNATIVE 1)	GROUNDWATER EXTRACTION AND TREATMENT (ALTERNATIVE 2)	GROUNDWATER EXTRACTION AND TREATMENT WITH NANOSCALE ZVI (ALTERNATIVE 3)	GROUNDWATER EXTRACTION AND TREATMENT WITH IN SITU BIOREMEDIATION, PRB WALLS AND MNA (ALTERNATIVE 4)
3. Long-Term Effectiveness and Permanence	• No institutional controls would be in place to protect against exposure to contaminated groundwater. • Current concentrations of chlorinated VOCs exceed chemical specific ARARs, and represent unacceptable risk.	• Long-term effectiveness of pump and treat systems alone for meeting restoration criteria is questionable based on studies by the National Research Council. • A groundwater restoration time of many decades is anticipated. • Treatment residues will be produced which are not expected to pose any further risk if handled and disposed properly.	• Groundwater extraction and treatment system will be complemented by source treatment through NZVI injection to reduce remedy timeframe. • NZVI injection will chemically destroy chlorinated solvents and reduce hexavalent chromium to trivalent chromium in groundwater with no byproducts requiring disposal. Long-term monitoring will be conducted to verify the continued performance of groundwater treatment. • Contingency measures are available to achieve long-term effectiveness should for future conditions dictate. • Timeframe for source treatment (and overall groundwater restoration) is dependent in part upon accessibility to source areas, as continued operational activities at the site currently limit access to some source areas.	• Groundwater extraction and treatment system will be complemented by source treatment through in situ bioremediation to reduce remedy timeframe. • Installation of PRB walls over time would provide protection of groundwater in areas where lower concentrations of contaminants render groundwater extraction and treatment less efficient. • This alternative will permanently remove constituents in groundwater through chemical and biological destruction and natural attenuation. Long-term monitoring will verify the continued effectiveness of natural attenuation. • Contingency measures are available to achieve long-term effectiveness should for future conditions dictate. • Timeframe for source treatment (and overall groundwater restoration) is dependent in part upon accessibility to source areas, as continued operational activities at the site currently limit access to some source areas.
4. Reduction of Toxicity, Mobility, or Volume through Treatment	• This alternative does not include implementation of any treatment technologies; therefore, would not provide reduction of toxicity, mobility, or volume through treatment.	• Groundwater extraction and treatment system will reduce the toxicity, mobility and volume of contaminants in extracted groundwater and would further limit migration to potential receptors. • Secondary wastes will be generated from energy source demands, and residuals from treatment processes.	• Groundwater extraction and treatment system will reduce the toxicity, mobility and volume of contaminants in extracted groundwater and would further limit migration to potential receptors. However, secondary wastes will be generated from energy source demands, and residuals from treatment processes. • Directly achieved by the chemical destruction of chlorinated solvents and reduction hexavalent chromium in groundwater with no byproducts requiring disposal.	• Groundwater extraction and treatment system will reduce the toxicity, mobility and volume of contaminants in extracted groundwater and would further limit migration to potential receptors. However, secondary wastes will be generated from energy source demands, and residuals from treatment processes. • Directly achieved by the biological and chemical destruction of chlorinated solvents and reduction hexavalent chromium in groundwater with no byproducts requiring disposal.

TABLE 4
ALTERNATIVE EVALUATION SUMMARY
FORMER BOEING WICHITA FACILITY

EVALUATION CRITERIA	PERFORMANCE NO ACTION (ALTERNATIVE 1)	GROUNDWATER EXTRACTION AND TREATMENT (ALTERNATIVE 2)	GROUNDWATER EXTRACTION AND TREATMENT WITH NANOSCALE ZVI (ALTERNATIVE 3)	GROUNDWATER EXTRACTION AND TREATMENT WITH IN SITU BIOREMEDIATION, PRB WALLS AND MNA (ALTERNATIVE 4)
5. Short-Term Effectiveness	• No short-term impact and risk to the community, construction workers, and ecology *from construction activities*, since no construction activities would be implemented in this alternative. • Remedial action objectives and chemical specific ARARs would not be achieved.	• Minimal short-term impact and risk to the community, construction workers, and ecology from construction activities, since groundwater extraction and treatment system is currently in operation.	• Minimal short-term impact and risk to the community, construction workers, and ecology from construction activities, since groundwater extraction and treatment system is currently in operation. • Installation of additional injection wells and periodic injection of NZVI would be expected to have minimal short-term impact and risk to the community, construction workers, and ecology.	• Minimal short-term impact and risk to the community, construction workers, and ecology from construction activities, since groundwater extraction and treatment system is currently in operation. • Installation of additional injection wells and periodic injection of electron donors would be expected to have minimal short-term impact and risk to the community, construction workers, and ecology. • Installation of PRB walls would have short-term risks associated with construction activities.

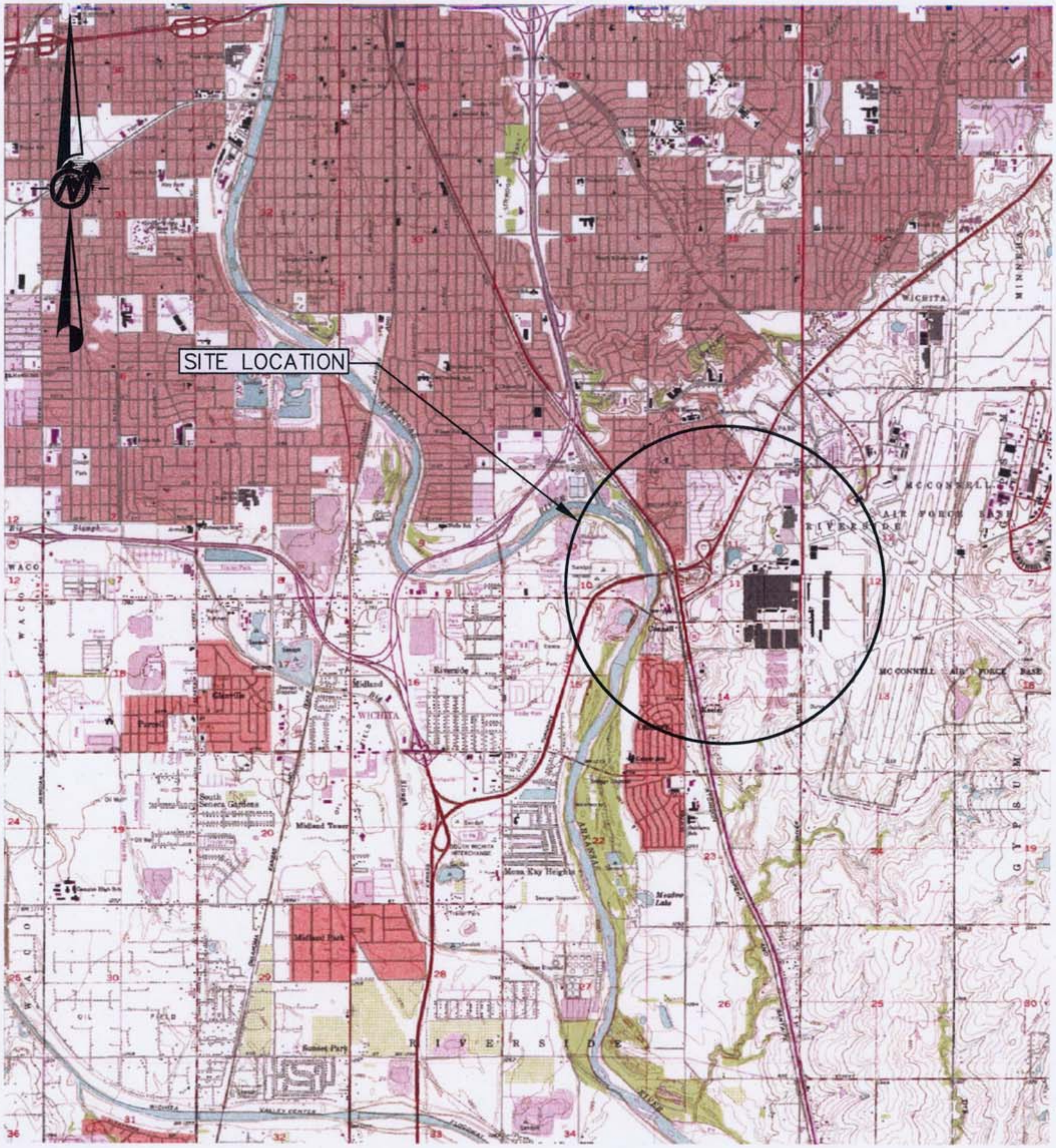
TABLE 4
ALTERNATIVE EVALUATION SUMMARY
FORMER BOEING WICHITA FACILITY

	PERFORMANCE			
EVALUATION CRITERIA	**NO ACTION (ALTERNATIVE 1)**	**GROUNDWATER EXTRACTION AND TREATMENT (ALTERNATIVE 2)**	**GROUNDWATER EXTRACTION AND TREATMENT WITH NANOSCALE ZVI (ALTERNATIVE 3)**	**GROUNDWATER EXTRACTION AND TREATMENT WITH IN SITU BIOREMEDIATION, PRB WALLS AND MNA (ALTERNATIVE 4)**
6. Implementability	• Alternative may be readily implemented since no actions would be performed.	• Alternative has been implemented and is currently in operation.	• Groundwater extraction and treatment system has been implemented and is currently in operation. • Contractors, vendors, and materials are readily available to supply NZVI for injection. • Installation of additional injection wells and application of UIC permits is expected to take approximately 6 months. • Performance monitoring associated with NZVI injection can be readily implemented.	• Groundwater extraction and treatment system has been implemented and is currently in operation. • Contractors, vendors, and materials are readily available to supply ZVI and electron donor amendments. • Construction of PRB walls would take approximately 6 months per wall. • Installation of additional injection wells and application of UIC permits is expected to take approximately 6 months. • Performance monitoring associated with MNA can be readily implemented.
7. Cost	• None	• $17,000,000	• $15,000,000	• $13,000,000
8. State and Community Acceptance	• To be re-evaluated based on new information provided in RFS. • Substantial community concerns are expected to result from lack of overall protection of human health and the environmental and failure to achieve ARARs.	• To be re-evaluated based on information provided in RFS. • Community is expected to have limited concern with this alternative as it can be readily implemented, has minimal impact on the community from construction and O&M activities, while being protective of human health and the environment.	• To be re-evaluated based on new information provided in RFS. • Community is expected to have limited concern with this alternative as it can be readily implemented, has minimal impact on the community from construction and O&M activities, while being protective of human health and the environment.	• To be re-evaluated based on new information provided in RFS. • Community is expected to have limited concern with this alternative as it can be readily implemented, has minimal impact on the community from construction and O&M activities, while being protective of human health and the environment.

TABLE 5
COMPARISON OF ALTERNATIVES
FORMER BOEING FACILITY, WICHITA, KANSAS

Criteria	Alternative 1 No Action	Alternative 2 Groundwater Extraction and Treatment	Alternative 3 Groundwater Extraction and Treatment with Nanoscale ZVI	Alternative 4 Groundwater Extraction and Treatment with In Situ Bioremediation, PRB Walls and MNA
Overall Protection of Human Health and the Environment	No	Yes	Yes	Yes
Compliance with ARARs	No	Yes	Yes	Yes
Long-Term Effectiveness and Permanence	Poor	Fair	Good	Good
Reduction of Toxicity, Mobility, or Volume through Treatment	Poor	Good	Good	Excellent
Short-Term Effectiveness	Poor	Good	Good	Good
Implementability	Excellent	Excellent	Good	Good
Cost	Excellent	Poor	Poor	Fair
State and Community Acceptance	To be determined based on information provided in RFS			

FIGURES



REFERENCES

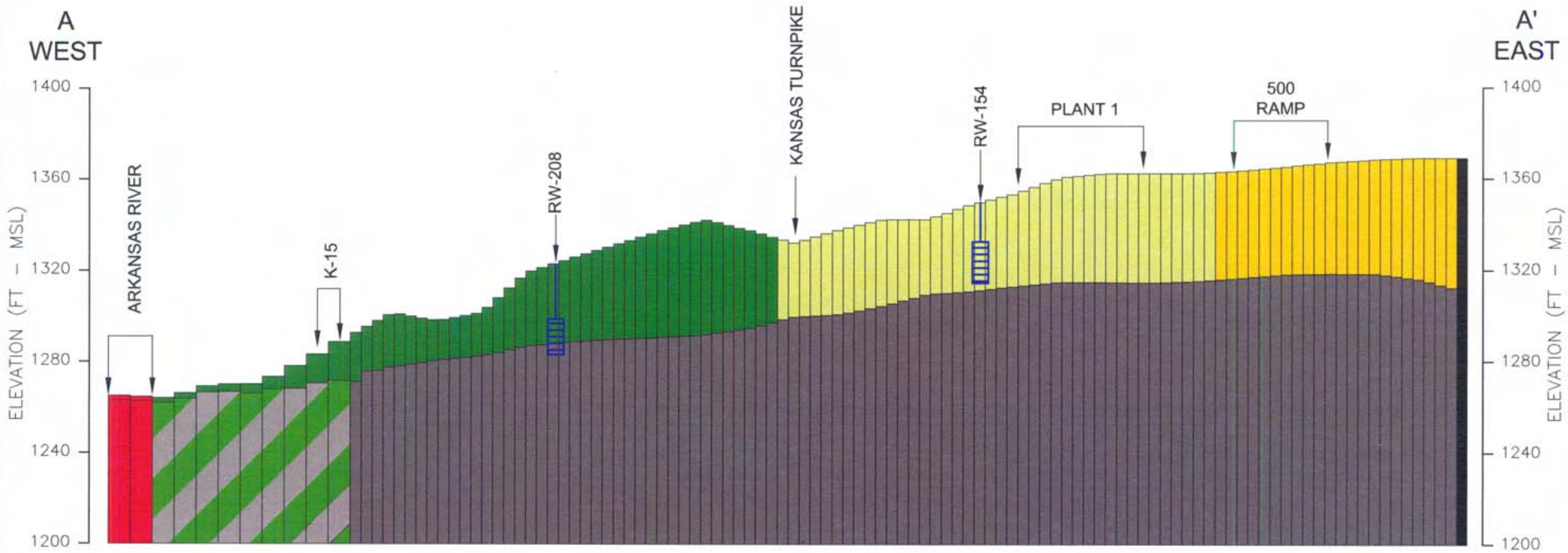
BASE MAPS TAKEN FROM 7.5 MINUTE USGS QUADRANGLE MAPS TITLED, "DERBY, KS.", DATED 1961. AND "WICHITA EAST, KS" DATED 1960.

5000 0 5000
SCALE APPROXIMATE FEET

Golder Associates, Manchester, New Hampshire	SCALE: AS SHOWN	TITLE: **SITE LOCATION MAP**		
	DATE: 08/21/09			
	DESIGN: RWB			
	CADD: MPB			
FILE No.: 09381501A008	CHECK: RWB	THE BOEING COMPANY BOEING AND MCCONNELL AIR FORCE BASE WICHITA, KANSAS	FIGURE	1
PROJECT No.: 093-81501 REV. 0	REVIEW: THR			

Drawing file: 09381501A008.dwg Aug 21, 2009 - 4:24pm

Drawing file: 09381501E003.dwg Jan 19, 2010 - 8:58am



CROSS-SECTION ALONG MODEL ROW 84

LEGEND

- MODEL GRID CELLS
- NO FLOW BOUNDARY
- RIVER BOUNDARY (ARKANSAS RIVER)
- BROWN CLAY
- FLUVIAL DEPOSITS
- OLIVE CLAY
- BEDROCK
- BEDROCK AND FLUVIAL DEPOSITS (INTERFACE UNKNOWN)
- EXISTING RECOVERY WELL

NOTE

1. SITE FEATURES AND SCALE ARE APPROXIMATE.

1000 0 1000

SCALE FEET

VERTICAL SCALE EXAGGERATED 15X

PROJECT

THE BOEING COMPANY
WICHITA, KANSAS

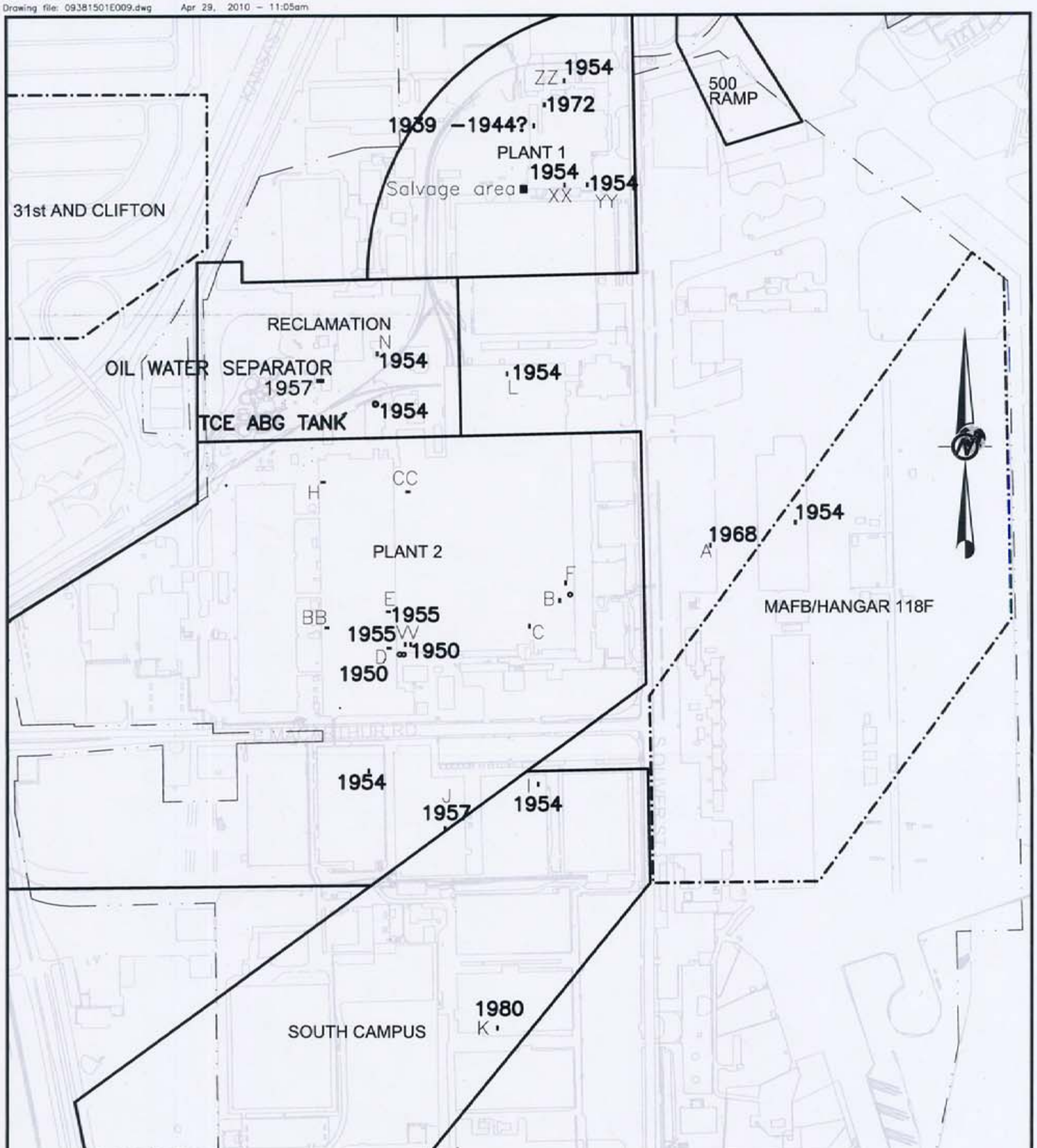
TITLE

**CONCEPTUAL
GEOLOGIC CROSS SECTION**

Golder Associates
Manchester, New Hampshire

PROJECT No.		093-81501	FILE No.	09381501E003
DESIGN	RWB	08/20/09	SCALE AS SHOWN	REV. 0
CADD	BCL	01/08/10		
CHECK	RWB	08/21/09	FIGURE 2	
REVIEW	THR	08/21/09		

Drawing file: 09381501E009.dwg   Apr 29, 2010 - 11:05am



LEGEND

— · · — APPROXIMATE BOEING PROPERTY BOUNDARY

— · — AREAS NOT INCLUDED

——— SUB AREA BOUNDARY

REFERENCES

1.) FORMER DEGREASER LOCATIONS BASED ON CAD FILE TITLED, "SOURCE2.DWG" PROVIDED BY THE BOEING COMPANY".

2.) BASE MAP FROM CADD FILE TITLED "NEWBASEMAP2.DWG", PROVIDED BY THE BOEING COMPANY.

3.) EXTENT OF STREAMS AND RIVERS BASED ON CADD FILE TITLED "STREAMS.DXF" PROVIDED BY FRANZ ENVIRONMENTAL INC.

600 0 600
SCALE FEET

FIGURE 3

PROJECT No. 093-81501
FILE No. 09381501E009
REV. 0 SCALE AS SHOWN
DESIGN RWB 04/29/10
CADD MPB 04/29/10
CHECK
REVIEW

TITLE
EXISTING AND/OR HISTORIC VAPOR DEGREASER LOCATIONS

PROJECT
THE BOEING COMPANY
WICHITA, KANSAS

Golder Associates
Manchester, New Hampshire

Drawing file: 09381501E010.dwg Apr 29, 2010 - 11:04am

LEGEND

APPROXIMATE BOEING PROPERTY BOUNDARY

AREAS NOT INCLUDED

SUB AREA BOUNDARY

IWT MAINS

REFERENCES

1.) BASE MAP FROM CADD FILE TITLED "NEWBASEMAP2.DWG", PROVIDED BY THE BOEING COMPANY.

2.) EXTENT OF STREAMS AND RIVERS BASED ON CADD FILE TITLED "STREAMS.DXF" PROVIDED BY FRANZ ENVIRONMENTAL INC.

3.) IWT MAINS LOCATED BASED ON CADD FILES TITLED "1_u_sewer.dwg", "2_u_sewer.dwg", and "3_u_sewer.dwg" PROVIDED BY BOEING.

1000 0 1000

SCALE FEET

FIGURE 4

PROJECT No. 093-81501 | FILE No. 09381501E010 | REV. 0 | SCALE AS SHOWN | DESIGN RWB 04/29/10 | CADD MPB 04/29/10 | CHECK | REVIEW

TITLE

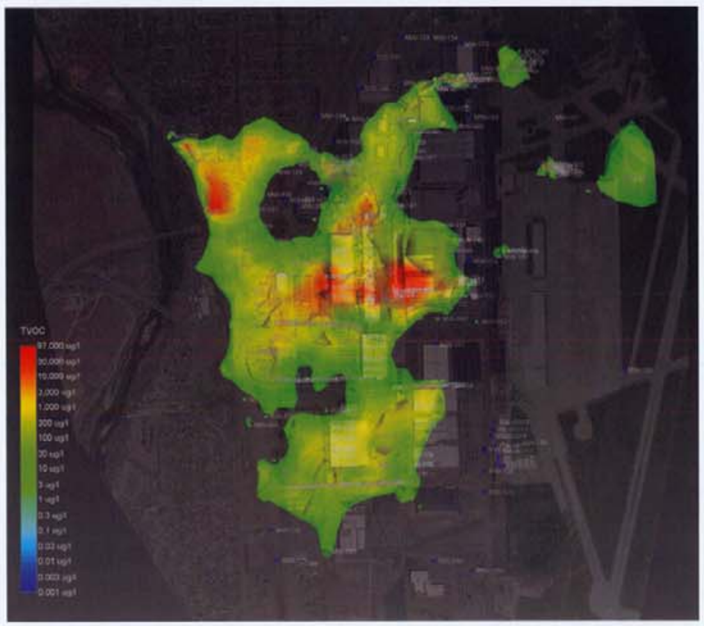
INDUSTRIAL WASTE TREATMENT PLANT MAIN PIPELINE LOCATIONS

PROJECT

THE BOEING COMPANY
WICHITA, KANSAS

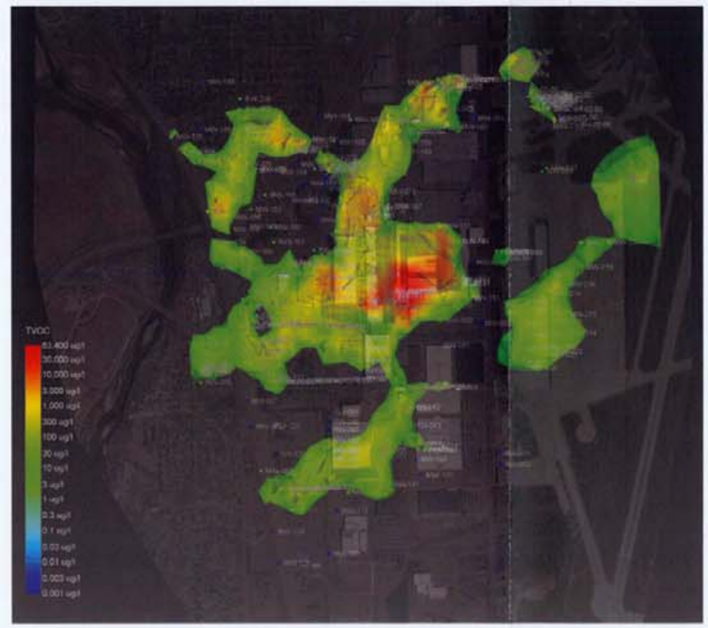
Golder Associates
Manchester, New Hampshire

1995



ESTIMATED TVOC MASS = 4,472 KILOGRAMS (DISSOLVED PHASE)

2008



ESTIMATED TVOC MASS = 2,750 KILOGRAMS (DISSOLVED PHASE)

2,000 0 2,000

SCALE FEET

Golder Associates
Manchester, New Hampshire

PROJECT

THE BOEING COMPANY
MODFLOW REPORT
WICHITA, KANSAS

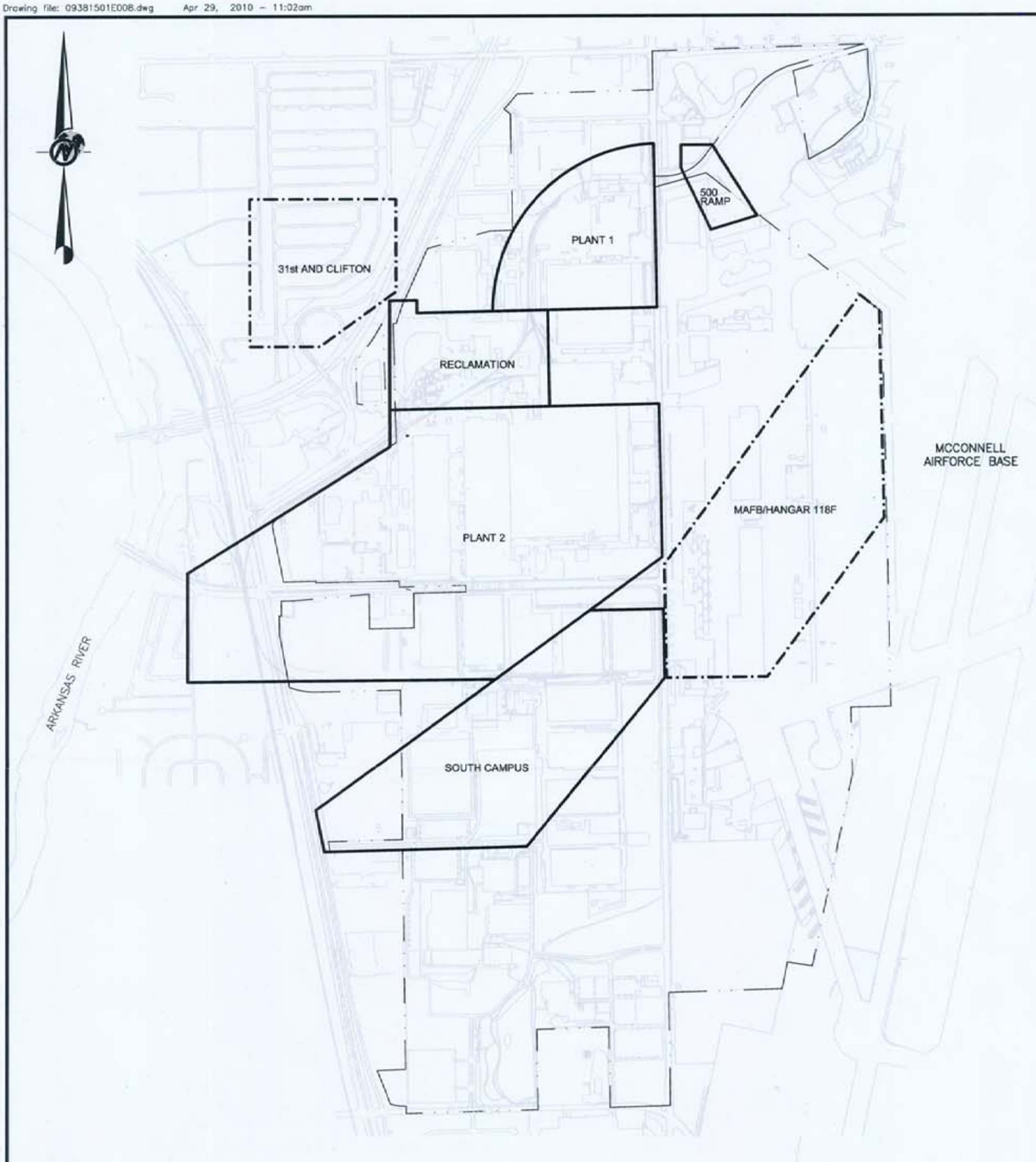
TITLE

ENTIRE SITE
TVOC > 10 MICROGRAMS PER LITER

PROJECT No. 093-81501		
FILE No.09381501-B001.F		
REV. 0	SCALE AS SHOWN	
DESIGN	BMW	12/17/09
CADD	PMD	12/17/09
CHECK		
REVIEW		

FIGURE 5

Drawing file: 09381501E008.dwg Apr 29, 2010 - 11:02am



LEGEND

- APPROXIMATE BOEING PROPERTY BOUNDARY
- AREAS NOT INCLUDED
- SUB AREA BOUNDARY

REFERENCES

1.) BASE MAP FROM CADD FILE TITLED "NEWBASEMAP2.DWG", PROVIDED BY THE BOEING COMPANY.

2.) EXTENT OF STREAMS AND RIVERS BASED ON CADD FILE TITLED "STREAMS.DXF" PROVIDED BY FRANZ ENVIRONMENTAL INC.

1000 0 1000

SCALE FEET

PROJECT No.	093-81501
FILE No.	09381501E008
REV. 0	SCALE AS SHOWN
DESIGN	RWB 04/29/10
CADD	MPB 04/29/10
CHECK	
REVIEW	

FIGURE 6

TITLE

SUB AREA DELINEATION MAP

PROJECT

THE BOEING COMPANY
WICHITA, KANSAS

Golder Associates
Manchester, New Hampshire

APPENDIX A

SUMMARY OF SOURCE CHARACTERIZATION, NATURE AND EXTENT INVESTIGATION, AND INTERIM REMEDIAL MEASURES

1.0 SUMMARY OF INTERIM REMEDIAL MEASURES AND PROSPECTIVE CORRECTIVE ACTIONS

The Site was divided into numerous sub areas (shown in Figure 6), which were delineated based on the geographic proximity of source areas and groundwater plume boundaries. The sub areas were not intended to delineate individual groundwater plumes, as boundaries often overlap where groundwater plumes coalesce. Instead, they were developed as a means to divide the Site into numerous functional areas, which may provide a more efficient process due to the size and complexity of the Site. The sub area boundaries were roughly based on the current groundwater plume boundaries; therefore, where historic monitoring wells and/or recovery wells were present outside the sub areas, they were typically included within the nearest sub area for descriptive purposes.

The sub areas are intended to serve as functional areas for description of historic IRM and management of future corrective actions. Due to the magnitude of historic data available for each sub area, the sections below provide only an overview of the important aspects of each sub area (additional information is available in the references cited in Section 6). Monitoring wells and recovery wells were typically sampled and analyzed on a quarterly basis following well installation. Once sufficient data were collected to indicate that the plume was defined and the groundwater extraction system was effective in providing for capture, the frequency of monitoring was reduced to semi-annual upon approval by KDHE (KDHE, 1999).

Corrective actions are presented below for each of the sub areas and are summarized in Table 1. The corrective actions specified are consistent with the recommended Alternative 4 of the RFS. The corrective actions are listed as either proposed corrective actions or prospective corrective actions. The proposed corrective actions have been implemented and their operation would continue, consistent with Alternative 4 of the RFS. The prospective corrective actions may be implemented as source treatment is achieved and these elements can be implemented to reduce reliance on the groundwater extraction and treatment system. For example, monitored natural attenuation (MNA) is included as a prospective corrective action for each of the sub areas; however, MNA may not be viable as a remedial element at this point. MNA is considered as a prospective corrective action in the future, if concentrations of constituents in groundwater continue to decrease and natural attenuation is demonstrated as an effective mechanism for achieving RAOs. Prior to implementation of prospective actions such as MNA, Boeing would submit a work plan for obtaining and evaluating the prospective action (e.g. collection of MNA parameters in accordance with KDHE-BER guidance and collection of appropriate information to determine whether MNA is viable for the sub-area(s) of concern). If this approach supports the viability of, for example, MNA as a remedial element, Boeing would receive KDHE approval prior to implementation, and incorporate MNA as a component of the Site remedial strategy.

1.1 South Campus Area

1.1.1 Source Characterization

The primary COCs within the South Campus Area are chlorinated ethenes (TCE, DCE, and VC) and hexavalent chromium. The known sources of chlorinated ethenes are the vapor degreasers located in buildings IPB2, Warehouse 1 and Warehouse 2 (Figure 3). The IWTP sewer line is also present within the South Campus Area and was the source for hexavalent chromium. The IWTP lines have been replaced over time with double-lined stainless steel and/or fiberglass lines to mitigate future releases. During previous construction activities when the IWTP line was replaced from south of Warehouse 2 to the IWTP in the early 1990's, stained and discolored soil was observed immediately adjacent to the IWTP line in various areas. Stained and discolored soil was observed along the IWTP line south of Warehouse 2 and west of the CMF Building. All stained and discolored soil was removed during construction and disposed of as hazardous waste.

The closed 440 Landfill is also located within the South Campus Area to the east of the Assembly Support Building (ASB) (Figure 6). Analytical data collected from borings, monitoring wells, and recovery wells indicate that the sludge pits that comprised the 440 Landfill have not impacted the groundwater; therefore the 440 Landfill is not a known source for contamination within the South Campus Area.

1.1.2 Nature and Extent Investigations

Characterization of the nature and extent of groundwater contamination within the South Campus Area began with installation of ten monitoring wells (MW-001, MW-002, MW-003, MW-024, MW-025, MW-029, MW-042, MW-043, MW-044 and MW-048) in November 1985 and January through March 1986 (Table A-1). Analytical data indicated groundwater contamination was present within the South Campus Area. Additional borings (BH 96-49, BH 96-50, BH 96-51, BH 96-52, BH 96-53, BH 96-54, BH 96-55, BH 96-56, BH 96-57 and BH 96-58) and monitoring wells (MW-092, MW-093, MW-094, MW-094R, MW-095, MW-095R, MW-095A, MW-135, MW-136, MW-137, MW-138, MW-139, MW-140, MW-141, MW-175, MW-193, MW-194, MW-195 and MW-204) were installed from 1989 to 2007 to further delineate and monitor the groundwater contamination present within the South Campus Area.

Monitoring well MW-24A has been used to monitor the South Campus site since November 2002. The original monitoring well (MW-24) did not penetrate the Wellington Shale; therefore, it was replaced by installing MW-024A next to MW-024. Evaluation of laboratory analytical data collected from the two monitoring wells for several years confirmed that MW-024A would accurately monitor the plume, so MW-024 was subsequently plugged on November 15, 2004. TVOC concentrations in MW-24A have declined from 308 ppb in November 1990 to 36.4 ppb in August 2009.

1.1.3 Interim Remedial Measures

Following initial characterization of COCs in groundwater, 13 recovery wells (RW-032, RW-033, RW-034, RW-035, RW-036, RW-037, RW-038, RW-039, RW-040, RW-041, RW-042, RW-043 and RW-044) were installed within the South Campus Area during September 1987 to capture the groundwater contamination. Produced water from the recovery wells was pumped to a packed tower air stripper located approximately 0.75 miles north of the South Campus Area near the Boeing Radio Shop. The Boeing Radio Shop air stripper began treating water in September 1986 from recovery wells installed in the South Campus, Plant 2 and Reclamation Areas.

As described in Section 2.3.4, an aquifer test was conducted in May 1992 to optimize the spacing of recovery wells at the Site. Based on the results of this test, 27 additional recovery wells were installed (spaced approximately 150 feet apart) within the South Campus Area in 1992 to increase groundwater capture (shown in Table A-2).

The recovery well network was further expanded with the addition of 45 recovery wells (shown in Table A-2) in 1993, 1994, 1996, and 1997 to increase the effectiveness of the IRM within the South Campus Area. Five replacement recovery wells (RW-161R, RW-162R, RW-163R, RW-164R and RW-165R) were installed during 2006 and 2007 due to construction activities within the South Campus Area. These replacement recovery wells were installed upon completion of construction activities as close to the original locations as site conditions would allow.

Several air strippers have been installed within the South Campus Area. The South Campus air stripper, installed in 1992, is comprised of four individual recovery well systems pumping groundwater to the air stripper, including (i) the East Warehouse "O" system that began pumping in August 1992, (ii) the Glickman system which began pumping in October 1992, (iii) the Humane Society system that started pumping in January 1993, and (iv) the Humane Society/440LF system that began pumping in June 1994. The South Campus groundwater recovery system processed 9,841,089 gallons of water in 2008. Total cumulative produced water from the South Campus air stripper through 2008 was 294,068,915 gallons. The IPB-2 air stripper was installed in 1997 and receives groundwater extracted from recovery wells RW-183, RW-184, RW-185, RW-186 and RW-187. The IPB-2 groundwater recovery system processed 4,153,743 gallons of water in 2008. Total cumulative produced water from the IPB-2 system through 2008 was 46,815,969 gallons.

In the South Campus Sub Area, the IPB-2 recovery system was installed with a permanent dual phase extraction system. Substantial decreases were observed in recovery wells and monitoring wells within the IPB-2 area following operation of the dual phase extraction system. Based on the results observed, dual phase extraction was incorporated into other existing recovery wells within the South Campus Area and across the Site beginning in 1997, through the installation of numerous mobile blowers. The blowers were rotated across the Site to target wells with elevated concentrations of VOCs. Detailed operational and analytical data for individual wells using dual phase extraction is available in the annual reports for the Site.

TVOC concentrations within the South Campus plume declined substantially following implementation of the IRM. The footprint of the plume has been diminished as well, as indicated by Figure A-1. The decreased footprint of the South Campus Area plume coincides with a decrease in the overall mass of the groundwater plume, from approximately 125 kg TVOC in 1995 to approximately 22 kg TVOC in 2008, based on estimates obtained using EVS software (Figure A-1).

As described above, contaminated soil was observed and removed during construction activities near the IWTP line. It should be noted that during construction activities at the Former Boeing Wichita Facility, if a contractor observes any contamination while excavating the contractor is to stop construction activities and contact Boeing personnel. Contaminated soil is removed and properly disposed of before construction is allowed to continue.

1.1.4 Prospective Corrective Actions

Groundwater analytical data collected from monitoring wells and recovery wells within the South Campus Area demonstrates the effectiveness of the existing groundwater extraction system. Substantial reductions in VOC concentrations have been observed within individual wells over time, and both the footprint and mass of the groundwater plume have been substantially reduced.

Based on the historic effectiveness of the IRM, groundwater extraction and treatment will continue to be the primary corrective action within the South Campus Area. However, the existing groundwater extraction system can be optimized to increase the efficiency of the system. An OWP was submitted to KDHE in September 2009 that presents a strategy and schedule for minimizing potential redundancy in the groundwater extraction system (Golder, 2009). The OWP recommends that recovery wells RW-033, RW-079, RW-080, RW-081, RW-082, RW-085 and RW-087 would continue to be active within the South Campus Area to provide groundwater capture. Groundwater monitoring will continue to be performed in the South Campus Area (with the frequency and well network specified in the OWP), to evaluate changes in groundwater plume dynamics and allow for further evaluation of the ability to maintain groundwater capture under the modified recovery well network.

Additional remedial elements may be incorporated into the remedial strategy at the South Campus Area as the groundwater plume continues to diminish. A permeable reactive barrier (PRB) consisting of zero-valent iron (ZVI) is currently under consideration as a prospective corrective action to control off site migration of the groundwater plume within the downgradient region of the South Campus Area. Monitored natural attenuation (MNA) may also be considered as a prospective corrective action in the future, if concentrations of constituents in groundwater continue to decrease and natural attenuation is demonstrated as an effective mechanism for achieving RAOs. Prior to implementation of MNA, Boeing would submit a work plan for obtaining and evaluating MNA parameters (in accordance with KDHE-BER guidance) and collect appropriate information to evaluate whether MNA is viable at the Site for the sub-area(s) of concern. If this approach supports the viability of MNA as a remedial element, Boeing would receive KDHE approval prior to implementation, and incorporate MNA as a component of the Site remedial strategy.

1.2 Plant 2 Area

1.2.1 Source Characterization

The primary COCs within the Plant 2 Area are chlorinated ethenes (PCE, TCE, DCE ,and VC), chlorinated methanes (CT and chloroform), petroleum hydrocarbons and hexavalent chromium. The potential sources of chlorinated ethenes are the 11 vapor degreasers and two industrial waste sumps located in Plant 2 (Figure 3). Numerous monitoring and recovery wells were installed to delineate the source areas for implementation of the IRM (described in Section 3.2.3). Relatively low concentrations of chlorinated methanes were observed and the source was not identified. The potential sources of hexavalent chromium in the Plant 2 Area are IWTP lines. The IWTP lines have been replaced over time with double-lined stainless steel and/or fiberglass lines to mitigate future releases. Petroleum hydrocarbons were periodically observed in recovery wells RW-005A and RW-030 and monitoring well MW-007A; however, petroleum hydrocarbon concentrations are currently below detection limits in these wells and a source was not identified. Numerous monitoring wells were installed to characterize the source areas and downgradient groundwater plumes, as described in the section below.

1.2.2 Nature and Extent Investigations

Characterization of the nature and extent of groundwater contamination within the Plant 2 Area began with installation of 38 monitoring wells in 1985 and 1986 (Table A-1). Several locations (MW-020, MW-021 and MW-022) had nested wells with shallow (designated as MW-020A), intermediate (MW-020B) and deep (MW-020C) screened intervals. Analytical data indicated groundwater contamination was present within the Plant 2 Area. Monitoring wells MW-007A, MW-008A, MW-0015A and MW-018A were installed to replace MW-007, MW-008, MW-0015 and MW-018 in 1989 and 1994. Monitoring wells MW-53 and MW-54 were installed in 1998 to further delineate the groundwater plume near the IWTP. Between 1991 and 1994, 24 monitoring wells were installed within the Plant 2 Area to further define the groundwater contamination. An additional 8 monitoring wells were installed between 1998 and 2006.

1.2.3 Interim Remedial Measures

1.2.3.1 Groundwater Extraction and Treatment

Following initial characterization of COCs in groundwater, 24 recovery wells (shown in Table A-2) were installed within the Plant 2 Area during September 1987 to capture the groundwater contamination. Produced water from the recovery wells was pumped to a packed tower air stripper located approximately

0.75 miles north of the South Campus Area near the Boeing Radio Shop. The Boeing Radio Shop air stripper began treating water in September 1986 from recovery wells installed within the Plant 2 Area and South Campus Area.

As described in Section 2.3.4, an aquifer test was conducted in May 1992 to optimize the spacing of recovery wells at the Site. Based on the results of this test, 64 additional recovery wells were installed within the Plant 2 Area in 1992 and 1993 to increase groundwater capture (shown in Table A-2). Seven additional recovery wells were installed in 1998 and 1999 to enhance groundwater capture near the toe of the plume (RW-190, RW-191, RW-192, RW-193 and RW-194) and source treatment near a vapor degreaser (RW-188 and RW-189). The recovery well network was further expanded in 2002 along the western region of the Plant 2 Area with the installation of 6 recovery wells at the Englewood site (shown in Table A-2).

Four air strippers process the groundwater within the Plant 2 Area, including the Main air stripper, Plant 2 air stripper, South Campus air stripper, and Englewood air stripper. The Main air stripper (installed in August 1992) receives groundwater extracted from five individual recovery well systems, identified as the IWTP and Materials Building (which are part of the Reclamation Area), MFP, Parking Lot "N," and Warehouse "O." The Main recovery system processed 54,917,400 gallons of water in 2008. Total cumulative produced water through 2008 was 817,926,690 gallons. The Plant 2 air stripper (installed in February 1993) is comprised of seventeen individual recovery wells pumping groundwater to the air stripper. The Plant 2 recovery system processed 7,669,743 gallons of water in 2008. Total cumulative produced water through 2008 was 117,737,485 gallons. The Glickman property leg of the South Campus air stripper (installed in October 1992) is comprised of sixteen individual recovery wells pumping groundwater to the air stripper. The South Campus recovery system processed 9,841,089 gallons of water in 2008. Total cumulative produced water to the end of 2008 is 294,068,915 gallons. The Englewood air stripper (installed in January 2003) is comprised of six individual recovery wells pumping groundwater to the air stripper. The Englewood recovery system processed 2,291,782 gallons of water in 2008. Total cumulative produced water through 2008 was 8,799,697 gallons.

TVOC concentrations within the Plant 2 plume declined substantially following implementation of the IRM. The footprint of the plume has been diminished as well, as indicated by Figure A-2. The decreased footprint of the Plant 2 Area plume coincides with a decrease in the overall mass of the groundwater plume, from approximately 3,431 kg TVOC in 1995 to approximately 2,476 kg TVOC in 2008, based on estimates obtained using EVS software (Figure A-2).

1.2.3.2 Soil Excavation

Maintenance of IWTP lift stations resulted in observation of chromium contaminated soil. Excavation of contaminated soil was conducted in the Plant 2 Area in the late 1990s during maintenance of the IWTP line. Visually stained soil was removed and sent for off-site disposal.

1.2.3.3 In Situ Bioremediation

An in situ treatment program was implemented in the Plant 2 Area in July 2009, which consists of monthly injection of electron donors to support anaerobic microbial reduction of TCE and hexavalent chromium. The work plan was submitted to KDHE on February 23, 2007 (Golder, 2007) and approved by KDHE in an email to Boeing on March 30, 2007 (KDHE, 2007). Golder submitted a request for modification of the Underground Injection Control (UIC) permit for the Site (initially obtained for the 500 Ramp in situ treatment program) on April 3, 2007 (Golder, 2007) and requested a further modification on January 15, 2009, and KDHE-BOW indicated that the file would be updated per an email on January 16, 2009 (KDHE, 2009).

The in situ treatment program within the Plant 2 Area was implemented in 2009. Although the program is still early in its development, the initial data collected suggests that the process has been effective to date, based on reduction of both TCE and hexavalent chromium. For example, decreases in TVOC concentrations from 21,800 ug/L to 6,400 ug/L and 1,400 ug/L were observed in injection well RW-132, between September 2008 and September 2009. The decrease in TVOC concentrations was the result of microbial reductive dechlorination of TCE, as decreases in TCE (from 21,800 ug/L to 1,400 ug/L) were accompanied by increases in cDCE (from below detection limit [ND] to 4,000 ug/L) and VC (from ND to 1,000 ug/L) in RW-132 over this period. Decreases in dissolved chromium (from 73 ug/L to ND [less than 5 ug/L]) and total chromium (from 97 ug/L to 11 ug/L) were also observed in RW-132 between September 2008 and September 2009.

The decreases in TVOC and chromium concentrations correspond with increases in TOC, which is a reflection of the electron donor amendment, and generation of strongly reducing conditions in the aquifer, based on relatively low ORP values and the presence of methane. Similar trends observed TVOC and chromium concentrations (and general groundwater chemistry) were also observed in injection wells RW-128, RW-134 and RW-136.

1.2.3.4 Zero Valent Iron Injection

Boeing implemented an ZVI injection pilot test program in 2006 as an IRM at the Englewood Site, located within the western region of the Plant 2 Area. The pilot test program was conducted to evaluate the effectiveness of injecting ZVI for treatment of chlorinated ethenes in groundwater. Golder submitted a pilot test work plan to KDHE on April 12, 2006 for injection of ZVI at the site, and received KDHE approval in a letter dated May 18, 2006. On behalf of Boeing, Golder requested KDHE approval to perform a second ZVI injection event in a letter on November 2, 2007, and received KDHE approval on November 28, 2007.

Geotechnical Services Inc. (GSI) installed six injection wells (IWE-1, IWE-2, IWE-3, IWW-1, IWW-2 and IWW-3) via direct push injection in June 2006. Four additional performance monitoring wells (MW-200, MW-201, MW-202 and MW-203) were installed to evaluate the effectiveness of the ZVI pilot test program prior to ZVI injection. Injection of the ZVI was conducted at the Site in October 2006 and December 2007. Continental Analytical Services, Inc. (CAS) collected and analyzed groundwater samples from the injection wells and monitoring wells from November 2006 through September 2008 for evaluation of the effectiveness of the treatment program.

A data summary report previously documented the results of the pilot test program (Golder, 2009); therefore, only an overview is presented herein. Data collected from the injection points within the pilot test area were consistent with the bench test results indicating that ZVI is effective for reducing concentrations of TCE. However, the reductions in TCE concentrations observed at the downgradient monitoring wells were limited relative to those observed at the injection wells. In addition, the specific reductions in TCE concentrations varied between downgradient monitoring wells. The limited and varied reductions in TCE concentrations may have been due to heterogeneity in the aquifer properties between the injection points and the monitoring wells, potentially limiting ZVI distribution. These results indicate that this treatment technology may be useful for limited application at the Site in areas where aquifer hydrogeologic properties are suitable for adequate distribution of ZVI particles in the subsurface.

1.2.4 Prospective Corrective Actions

The groundwater analytical data collected from monitoring wells and recovery wells within the Plant 2 Area demonstrates the effectiveness of the existing groundwater extraction system. Substantial reductions in VOC concentrations have been observed within individual wells over time, and both the footprint and mass of the groundwater plume have been substantially reduced. The groundwater extraction system has been effective to date in providing groundwater capture within the Plant 2 Area; however, despite the reduction observed, a substantial mass of VOCs remains present in localized source areas. Therefore, the proposed corrective action for the Plant 2 Area will include groundwater extraction and treatment (for plume management) and in situ accelerated bioremediation (for source treatment).

Based on the historic effectiveness of the IRM, groundwater extraction and treatment will continue to be an important remedial element within the Plant 2 Area. However, the existing groundwater extraction system can be optimized to increase the efficiency of the system, based on recommendations presented in the OWP (Golder 2009). The OWP recommends that recovery wells RW-004A, RW-011A, RW-026, RW-028A, RW-049A, RW-058, RW-060, RW-061, RW-062, RW-066, RW-070, RW-097, RW-098, RW-116, RW-127, RW-192, RW-193, RW-194, RW-195, RW-196, RW-197, RW-198, RW-199 and RW-200 continue to be active within the Plant 2 Area to provide groundwater capture (Table A-2). Groundwater monitoring will continue to be performed in the Plant 2 Area (with the frequency and well network specified in the OWP), to evaluate changes in groundwater plume dynamics and allow for further evaluation of the ability to maintain groundwater capture under the modified recovery well network.

Proposed corrective actions in the Plant 2 Area will include continuation of the existing in situ accelerated bioremediation program within source areas of TCE and hexavalent chromium. The existing in situ treatment program has only recently been implemented. Initial data indicates that the biological treatment processes are effective for reduction of TCE and hexavalent chromium; however, additional data collection is ongoing to evaluate the area of influence of the amendment in the subsurface. If necessary, expansion of the treatment area may be achieved through the staggered use of select injection and recovery wells to enhance advective flow and distribute the amendment within target areas. The MODFLOW groundwater model can be used to generate predictive simulations that will assist in the determination of which injection and recovery well pairs may achieve the most efficient distribution of the amendment within the subsurface.

The in situ bioremediation program may also be expanded to include the use of existing recovery wells located to the west of the Materials building (RW-018A, RW-103, and RW-106) as injection points. These wells are located near the center of the line of recovery wells, which would allow the staggered use of select injection and recovery wells to enhance advective flow and increase distribution of the amendment. The MODFLOW groundwater model can be used to generate predictive simulations that will assist in the determination of which injection and recovery well pairs may achieve the most efficient distribution of the amendment within the subsurface.

1.3 Reclamation Area

1.3.1 Source Characterization

The primary COCs within the Reclamation Area are chlorinated ethenes (PCE, TCE, DCE, and VC), chlorinated methanes (CT and chloroform), petroleum hydrocarbons and hexavalent chromium. The potential sources of chlorinated ethenes are two vapor degreasers located in Building 2-319M and Building 2-309L, and an above ground TCE storage tank located west of Building 2-309L (Figure 3). Petroleum hydrocarbons were observed by visual observation (rather than soil or groundwater analytical data) as coolant oil residue from aluminum chips located on the north dock of Building 2-303L. The potential sources of hexavalent chromium in the Reclamation Area are IWTP lines and industrial process tank lines. The IWTP lines have been replaced over time with double-lined stainless steel and/or fiberglass lines to mitigate future releases. Numerous monitoring wells were installed to characterize the source areas and downgradient groundwater plumes, as described in the section below.

Two sludge pits for Industrial Plant Treatment Plant waste are located within the Reclamation Area. Numerous investigation wells were installed in 1997 and/or 1998, the sludge pits were not determined to be a source for VOCs or hexavalent chromium.

1.3.2 Nature and Extent Investigations

Characterization of the nature and extent of groundwater contamination within the Reclamation Area began with installation of seven monitoring wells (MW-004, MW-005, MW-006, MW-035, MW-041, MW-046 and MW-047) in 1985 and 1986 (Table A-1). Analytical data indicated groundwater contamination was present within the Reclamation Area. Monitoring wells MW-004A, MW-005A, MW-006A and MW-041A were installed to replace MW-004, MW-005, MW-006 and MW-041 in 1990 and 1991. In addition, monitoring wells MW-080, MW-081, MW-096 MW-171 were installed in 1990 and 1991 to further delineate and monitor the groundwater contamination present within the Reclamation Area.

The presence of coolant oil likely resulted in the generation of strongly reducing geochemical conditions in the groundwater system. The coolant oil may be utilized as electron donors by indigenous microbes, which may support anaerobic reductive dechlorination of TCE, resulting in the accumulation of cDCE and VC in this area. The observation of these natural attenuation processes suggests the potential use of in situ bioremediation as a corrective action element to enhance source treatment.

1.3.3 Interim Remedial Measures

Following initial characterization of COCs in groundwater, recovery wells RW-13 and RW-14 were installed within the Reclamation Area in 1987 to capture the groundwater contamination. Produced water from the two recovery wells was initially pumped to the Boeing Radio Shop air stripper. The recovery well network was expanded in 1991 through 1993 with the installation of 14 recovery wells (Table A-2). The Main air stripper was installed in 1992 and receives groundwater extracted from five individual recovery well systems, two of which (IWTP and Materials Building) are located within the Reclamation Area, and three other systems are located within the Plant 2 Area (MFP, Parking Lot "N" and Warehouse "O"). Produced water from the 14 additional recovery wells and the initial two recovery wells RW-13 (which was replaced by RW-13A in 1991) and RW-14 was then routed to the Main air stripper. The Main recovery system processed 54,917,400 gallons of water in 2008. Total cumulative produced water through 2008 was 817,926,690 gallons.

Soil excavation was conducted in 1990 to remove soil impacted by coolant oil within the lower dock area near Building 2-303L. Visually stained soil was removed and sent for off-site disposal, and this area was subsequently paved.

TVOC concentrations within the Reclamation plume declined substantially following implementation of the IRM. The footprint of the plume has been diminished as well, as indicated by Figure A-3. The decreased footprint of the Reclamation Area plume coincides with a decrease in the overall mass of the groundwater plume, from approximately 201 kg TVOC in 1995 to approximately 112 kg TVOC in 2008, based on estimates obtained using EVS software (Figure A-3).

1.3.4 Prospective Corrective Actions

The groundwater analytical data collected from monitoring wells and recovery wells within the Reclamation Area demonstrates the effectiveness of the existing groundwater extraction system. Substantial reductions in VOC concentrations have been observed within individual wells over time, and both the footprint and mass of the groundwater plume have been substantially reduced. The groundwater extraction system has been effective to date in providing groundwater capture within the Reclamation Area; however, despite the reduction observed, a substantial mass of VOCs remains present in localized source areas. Therefore, the proposed corrective action for the Reclamation Area will include groundwater extraction and treatment (for plume management) and in situ accelerated bioremediation (for source treatment).

Based on the historic effectiveness of the IRM, groundwater extraction and treatment will continue to be an important remedial element within the Reclamation Area. However, the existing groundwater extraction system can be optimized to increase the efficiency of the system, based on recommendations presented in the OWP (Golder 2009). The OWP recommends that recovery wells RW-012A, RW-019A, RW-045, RW-046A, RW-047A, RW-101, RW-142, RW-143, RW-053, RW-054, RW-055, RW-057, RW-093, RW-094, RW-095 and RW-096 would continue to be active within the Reclamation Area to provide groundwater capture. Groundwater monitoring will continue to be performed in the Reclamation Area (with the frequency and well network specified in the OWP), to evaluate changes in groundwater plume dynamics and allow for further evaluation of the ability to maintain groundwater capture under the modified recovery well network.

Proposed corrective actions in the Reclamation Area also include implementation of an in situ accelerated bioremediation program within select areas for treatment of TCE and hexavalent chromium. The infrastructure in this area will likely limit the ability to install injection points; however, the area near the loading ramp has elevated concentrations of chlorinated ethenes and is currently a candidate for potential in situ source treatment activities.

1.4 Plant 1 Area

1.4.1 Source Characterization

The primary COCs within the Plant 1 Area are chlorinated ethenes (TCE, DCE and VC), chlorinated methanes (CT and chloroform) and hexavalent chromium. The potential sources of chlorinated ethenes are the five vapor degreasers located in Plant 1 and 1-315C building (Figure 3). The potential sources of hexavalent chromium in the Plant 1 Area are IWTP lines and industrial process tank lines. The IWTP lines have been replaced over time with double-lined stainless steel and/or fiberglass lines to mitigate future releases. Numerous monitoring wells were installed to characterize the source areas and downgradient groundwater plumes, as described in the section below.

1.4.2 Nature and Extent Investigations

Characterization of the nature and extent of groundwater contamination within the Plant 1 Area began with installation of 23 monitoring wells (shown in Table A-1) in 1990. In addition, monitoring wells MW-165 and MW-170 (a deep monitoring well discussed in Section 2.4) were installed in 1993. Seven (MW-057, MW-170, MW-071, MW-072, MW-072S, MW-073 and MW-077) of the 25 monitoring wells in the Plant 1 Area were plugged (per KDHE protocol) since COCs were below detection limits.

Monitoring wells and recovery wells were sampled and analyzed on a quarterly basis following well installation. Once sufficient data was collected to indicate that the plume was defined and the groundwater extraction system was effective in providing for capture, the frequency of monitoring was reduced to semi-annual upon approval by KDHE (KDHE, 1999).

1.4.3 Interim Remedial Measures

Following initial characterization of COCs in groundwater, monitoring well MW-063 was converted to a recovery well (and renamed RW-149) in 1990. Eleven additional recovery wells (RW-150, RW-151, RW-152, RW-153, RW-154, RW-155, RW-156, RW-157, RW-158, RW-159 and RW-160) were installed within the Plant 1 Area in November and December 1993 to further capture the groundwater contamination. Produced water from the recovery wells is pumped to the Plant 1 air stripper, which was installed in April 1994 and is located to the northeast of Building 1-258H. The Plant 1 Area groundwater extraction and treatment system is currently comprised of 13 recovery wells pumping groundwater to the air stripper. The Plant 1 Area treatment system processed 701,123 gallons of water in 2008. Total cumulative produced water through 2008 was 14,222,312 gallons.

TVOC concentrations within the Plant 1 Area plume declined substantially following implementation of the IRM. The footprint of the plume has been diminished as well, as indicated by Figure A-4. The decreased footprint of the Plant 1 Area plume coincides with a decrease in the overall mass of the groundwater plume, from approximately 81 kg TVOC in 1995 to approximately 62 kg TVOC in 2008, based on estimates obtained using EVS software (Figure A-4).

1.4.4 Prospective Corrective Actions

The groundwater analytical data collected from monitoring wells and recovery wells within the Plant 1 Area demonstrates the effectiveness of the existing groundwater extraction system. Reductions in VOC concentrations have been observed within individual wells over time, and the mass of the groundwater plume has been reduced.

Based on the historic effectiveness of the IRM, groundwater extraction and treatment will continue to be the primary corrective action within the Plant 1 Area. However, the existing groundwater extraction system can be optimized to increase the efficiency of the system. An OWP was submitted to KDHE in September 2009 that presents a strategy and schedule for minimizing potential redundancy in the groundwater extraction system (Golder, 2009). The OWP recommends that recovery wells RW-049, RW-052 and RW-053 continue to be active within the Plant 1 Area to provide groundwater capture. Groundwater monitoring will continue to be performed in the Plant 1 Area (with the frequency and well network specified in the OWP), to evaluate changes in groundwater plume dynamics and allow for further evaluation of the ability to maintain groundwater capture under the modified recovery well network.

The hydrogeology of the Plant 1 Area is characterized by relatively low permeability units that result in low groundwater flow velocities. The decreasing trends observed in contaminant concentrations, coupled with the low flow velocity and substantial distance from the property boundary, suggests that monitored natural attenuation (MNA) may also be considered as a corrective action in the future.

1.5 500 Ramp Area

1.5.1 Source Characterization

The primary COCs within the ~~Plant 1~~ 500 Ramp Area are chlorinated ethenes (TCE, DCE and VC) and petroleum hydrocarbons. The potential sources of chlorinated ethenes are historic aircraft maintenance activities within the 500 Ramp Area. Numerous borings were installed, which eliminated McConnell Air Force Base (MAFB) as an upgradient source. Further investigation revealed historic aerial photographs indicate stained concrete beneath aircraft positions. Additional investigations were focused on the these areas, and the source of groundwater contamination was identified near monitoring well BH 03-01.

1.5.2 Nature and Extent Investigations

Characterization of the nature and extent of groundwater contamination within the 500 Ramp Area began with installation of monitoring well MW-37 in January 1986, during the initial investigation at the Site. Several monitoring wells (MW-97S, MW-97D, MW-166, MW-167, MW-168, MW-169) were installed in 1991 through 1993 in the vicinity of the Activity Center, during evaluation of a potential property transfer that did not occur. Chlorinated ethenes were observed in these wells; however, the source was not determined. Further investigation was conducted along the MAFB property boundary with the installation of numerous additional borings in 2002 and 2003, to determine the source of groundwater contamination in the 500 Ramp Area. This investigation eliminated MAFB as an upgradient source and identified the source area near monitoring well BH 03-01. Numerous additional monitoring wells and injection wells were installed in 2003 through 2005, which further delineated the source area and downgradient groundwater plumes. The source area is located near monitoring well BH 03-01, with the groundwater plume extending primarily to the north toward the Activity Center through higher permeability areas within the fluvial deposits.

In addition to TCE, elevated concentrations of cDCE and VC (which are daughter products of TCE dechlorination) have been observed in the 500 Ramp Area. Groundwater in the 500 Ramp Area is characterized by strongly reducing geochemical conditions (based on low DO and ORP values) likely due to historic releases of petroleum hydrocarbons. The petroleum hydrocarbons may be utilized as electron donors by indigenous microbes, which may support anaerobic reductive dechlorination of TCE, resulting in the accumulation of cDCE and VC. The observation of these natural attenuation processes was important in the development of an in situ biological treatment strategy discussed below.

1.5.3 Interim Remedial Measures

Following the observation of COCs in groundwater at the Activity Center, recovery wells RW-145, RW-146 and RW-147 were installed in September 1993 to capture the groundwater contamination. Produced water from the recovery wells is pumped to the Activity Center air stripper, which was installed in May 1994. The groundwater extraction and treatment system is currently comprised of 3 recovery wells pumping groundwater to the air stripper. The Activity Center treatment system processed 223,020 gallons of water in 2008. Total cumulative produced water through 2008 is 4,801,754 gallons.

Boeing implemented an in situ accelerated bioremediation pilot test as an IRM within the 500 Ramp Area in 2003. The pilot test program involved data review and evaluation of appropriate remedial strategies for in situ treatment of chlorinated ethenes in groundwater. In situ accelerated bioremediation using anaerobic reductive dechlorination was selected as the preferred remedial approach at the site, due to existing natural attenuation processes identified within the groundwater system. To facilitate implementation of the pilot test program, a UIC permit application was submitted to KDHE in November 2003 and approved in December 2003. The pilot test field program was initiated in December 2003, and the treatment program is currently ongoing. Initially, nutrient injections were performed monthly in numerous injection wells; however, monthly nutrient injections have been limited to five injection wells since November 2005 due to decreasing concentrations of VOCs over time in the treatment area. Annual data summary reports have documented the progress of the pilot test program (Golder, 2009); therefore, only an overview is presented herein.

Groundwater monitoring in injection wells and monitoring wells has demonstrated a substantial decrease in the concentrations of TVOCs since the onset of the treatment. In addition, major shifts have occurred in the ratio of TCE to daughter products of microbial dechlorination, such as cDCE and VC. This indicates that the decreases in TVOCs observed at the site are due to microbial dechlorination processes, rather than abiotic processes such as dilution and dispersion of contaminants. In addition, ethene has been observed in monitoring and injection wells, indicating that complete microbial dechlorination of TCE is occurring at the site. The accelerated bioremediation treatment program was designed to provide a sufficient mass of nutrients at each injection point to support microbial reductive dechlorination processes at target concentrations in downgradient regions of the plume, following dispersion of nutrients throughout the formation over time. The observed patterns of the stepwise dechlorination of TCE and overall decrease in TVOC concentrations observed in monitoring wells located downgradient from injection wells indicates that the injection program has been successful in delivering nutrients to targeted regions of the formation.

Mining Visualization System software was used by Golder to model data collected prior to implementation of the treatment program (2003) and recent data (2008), to provide a visualization of the decrease in the footprint of the VOC groundwater plume, as shown on Figure A-5. TVOC concentrations above 100 ug/l and above 1,000 ug/L are shown for both time periods on Figure A-5. Evaluation of TVOC concentrations above 1,000 ug/L over time using the MVS software shows that source treatment has been effective and the plume mass has been reduced substantially over the course of the treatment program.

The treatment program has been effective in reducing the mass of VOCs in many wells throughout the treatment areas; however, substantial fluctuations in VOC concentrations were observed in monitoring well BH 03-01, which correlated with fluctuations in groundwater elevation. The patterns observed suggested the presence of residual VOC mass in vadose zone soils that was mobilized periodically as groundwater elevation increased. To address the suspected vadose zone soil contamination, Boeing installed an SVE system in this area in late 2008. TVOC concentrations decreased from 33,300 µg/L in November 2008 to 5,110 µg/L in May 2009 (Golder, 2009), which suggests that the SVE system was effective in addressing the presence of residual mass in the vadose zone. Future groundwater monitoring will continue to focus on this area to evaluate whether this remedy continues to be effective in further reducing VOC groundwater concentrations within the source area.

1.5.4 Prospective Corrective Actions

The proposed corrective actions in the 500 Ramp Area include continuation of the existing in situ accelerated bioremediation program and SVE system within the source area (near BH 03-01). In addition, the groundwater extraction and treatment system will continue to operate with recovery wells RW-145, RW-146 and RW-147. While this IRM has been effective in reducing concentrations of VOCs within the source zone, comparatively lower concentrations of VOCs continue to be observed to the west of the source area. A gap exists in this area where no injection wells are present; therefore, the proposed corrective action will include periodic amendment of electron donors into the subsurface through Direct Push Technology (DPT) injection, rather than construction of permanent injection wells. The use of DPT injection is favorable in this area since operational activities and infrastructure constraints are minimal, and the DPT points can be staggered to allow for injection of amendment into different points within the toe of the plume during each injection event.

The downgradient region of the toe of the 500 Ramp Area groundwater plume is located near the former Activity Center. A series of extraction wells is located in the area as a component of an IRM; however, the well yield has decreased over time. The relatively low concentrations of VOCs present in this area and the relatively low groundwater flow velocities predicted suggest that a PRB wall comprised of ZVI may be an effective corrective action to further mitigate downgradient transport.

1.6 MAFB/Hangar 118F Area

1.6.1 Source Characterization

The primary COCs within the McConnell Air Force Base/Hangar 118F Area are chlorinated ethenes (TCE and 1,1-DCE) and chlorinated methanes (CT and chloroform). The source(s) have not been identified to date; however, patterns of groundwater analytical data and hydrogeologic data (presented in Section 3.6.2) indicate that the source of chlorinated VOCs that occurs in the vicinity of the MAFB-Boeing property boundary lies upgradient of the property boundary on the MAFB property.

1.6.2 Nature and Extent Investigations

Previous groundwater quality investigations of this area have been undertaken by Boeing and MAFB. These investigations have included monitoring well installation, borehole sampling, temporary monitoring well installation, and groundwater sampling using Hydropunch II® technology. At the MAFB-Boeing property boundary, the VOC plume is characterized by the presence of CT and TCE, with lesser concentrations of 1,1–dichloroethene (1,1-DCE) and chloroform. Chloroform is a potential daughter product of CT dechlorination, and may be present as result of microbial reductive dechlorination of CT. Additional VOCs have been observed in the area, but at lower concentrations or with infrequent detections. The presence of CT, chloroform, and 1,1-DCE serve to distinguish the MAFB groundwater impacts from those observed in groundwater at other downgradient regions of the Boeing property (e.g., the absence of CT, chloroform and 1,1-DCE in monitoring wells MW-205 through MW-222).

Spatially, the extent of the VOC contamination at the MAFB-Boeing property boundary is defined by the presence of CT and TCE detected in monitoring wells on the Boeing property (MW-038[1], MW-178, MW-179, MW-180, MW-181, MW-182, MW-223, MW-224, and MW-225) and upgradient on the MAFB property (MW-30, MW-31, and MW-32). Figures A-6 and A-7 provide isoconcentration plots of CT and TCE, respectively, at the Site. The shapes of the plumes are controlled regionally by the topographic gradient and locally within the dipping sand layers of the alluvial deposits. From the MAFB-Boeing property boundary the CT impacts extend to the south and southwest, fingering out to monitoring well MW-223. The TCE impacts extend from the MAFB-Boeing property boundary through MW-223 and MW-218. This plume shape agrees with the hydrogeologic evaluation which indicates flow is to the southwest.

The plume at the MAFB-Boeing property boundary was further delineated by CT and TCE detections in groundwater sampled on the MAFB property using Hydropunch II® to collect groundwater samples (HDR, 2008). TCE and CT were detected in Hydropunch samples at concentrations up to 85.1 ug/l and 27.6 ug/l, respectively. The Hydropunch samples within MAFB's SWMU-207 area with the highest reported CT and TCE detections (HP-011 and HP-008) were located to the east and northeast,

[1] Monitoring wells MW-178 and MW-179 replaced monitoring well MW-038 in 1994.

upgradient of monitoring wells MW-178, MW-179 and MW-180, the MAFB-Boeing property boundary wells with the highest historical CT and TCE detections.

1.6.3 Interim Remedial Measures

No IRM have been initiated to date within the MAFB/Hangar 118F Area.

1.6.4 Prospective Corrective Actions

Boeing has provided the results of the nature and extent characterization to MAFB, which indicates that an unknown source exists on the MAFB property. Boeing will continue to investigate the nature and extent of groundwater contamination downgradient of the MAFB boundary on the Boeing property, and corrective actions will be evaluated and implemented if a source is identified on the Boeing property. However, no source has been identified to date on the Boeing property; therefore, no prospective corrective actions have been specified for this area. Boeing will continue to work with MAFB in an attempt to address and mitigate the continuing source of chlorinated VOCs on the MAFB property.

TABLES

TABLE A-1
EXISTING AND HISTORIC MONITORING WELLS

BOEING FACILITY
WICHITA, KANSAS

Plant 1

ID	Date Installed
B-001P	6/6/1990
B-002P	6/6/1990
B-003P	6/6/1990
B-004P	6/7/1990
B-005P	6/7/1990
B-006P	6/8/1990
B-007P	6/7/1990
MW-057	1/30/1990
MW-058	1/29/1990
MW-058A	9/15/1990
MW-059	1/26/1990
MW-061	1/25/1990
MW-061A	1/26/1990
MW-062	2/11/1990
MW-063	1/29/1990
MW-064	2/14/1990
MW-065	2/8/1990
MW-071	5/30/1990
MW-074	6/4/1990
MW-075	6/4/1990
MW-076	6/5/1990
MW-077	6/14/1990
MW-078	6/15/1990
MW-079	6/18/1990
MW-165	9/15/1993
MW-170	11/5/1993
RW-148	12/10/1993
RW-149	1/26/1990
RW-150	11/23/1993
RW-151	12/15/1993
RW-152	12/16/1993
RW-153	12/27/1993
RW-154	12/8/1993
RW-155	12/7/1993
RW-156	12/28/1993
RW-157	12/29/1993
RW-158	12/9/1993
RW-159	12/13/1993
RW-160	12/30/1993
Plant 1 Extended	
BH-97-19	6/17/1997
BH-97-20	6/19/1997
BH-97-21	6/16/1997
BH-97-22	6/12/1997
BH-97-23	6/13/1997
BH-97-24	6/16/1997
BH-98-20	6/12/1998
BH-98-21	5/18/1998
BH-98-22	5/18/1998
BH-98-23	5/15/1998
BH-98-24	5/15/1998
BH-98-26	6/16/1998
MW-040	1/29/1986
MW-060	1/26/1990
MW-066	2/2/1990
MW-066A	2/15/1990
MW-072	5/31/1990
MW-072S	6/1/1990
MW-073	5/31/1990
MW-105	10/29/1991
MW-106	11/5/1991
MW-107	11/6/1991
MW-133	12/16/1992
MW-134	12/16/1992

Reclamation

ID	Date Installed
MW-004	11/29/1985
MW-004A	12/20/1990
MW-005	12/2/1985
MW-005A	12/27/1990
MW-006	12/2/1985
MW-006A	1/22/1991
MW-035	2/5/1986
MW-041	2/5/1986
MW-041A	12/26/1990
MW-046	1986
MW-047	1986
MW-080	9/27/1990
MW-081	9/27/1990
MW-96	2/15/1991
MW-171	11/4/1993

31st and Clifton

ID	Date Installed
BH-97-07	2/27/1997
BH-97-09	2/25/1997
BH-97-10	2/27/1997
BH-97-13	2/28/1997
BH-97-25	9/3/1997
BH-97-26	9/2/1997
BH-97-27	8/6/1997
BH-97-28	8/6/1997
BH-97-30	9/3/1997
BH-98-16	5/11/1998
BH-98-17	5/11/1998
BH-98-18	5/11/1998
BH-98-19	5/8/1998
BH-98-28	6/25/1998
BH-98-CP-01	6/15/1998
BH-98-CP-02	6/10/1998
BH-98-CP-03	6/11/1998
BH-98-CP-04	6/10/1998
BH-98-CP-05	6/3/1998
BH-98-CP-06	6/8/1998
BH-98-CP-07	6/5/1998
BH-98-CP-08	6/5/1998
BH-98-CP-09	6/11/1998
BH-98-CP-10	6/4/1998
BH-98-CP-12	7/2/1998
BH-98-CP-13	6/30/1998
BH-98-CP-14	6/29/1998
BH-98-CP-15	6/26/1998
BH-98-CP-16	7/1/1998
MW-152	8/12/1993
MW-153	8/16/1993
MW-154	8/17/1993
MW-163	9/13/1993
MW-164	9/14/1993
MW-190	2/28/1997
MW-191	3/5/1997
31st and Clifton Extended	
B-082J	9/20/1990
B-082K	10/4/1990
B-083A	9/17/1990
B-083B	9/17/1990
B-083C	9/18/1990
B-083D	9/18/1990
B-083E	9/18/1990
B-083F	9/18/1990
B-083G	9/18/1990
B-083H	9/19/1990
B-083I	9/19/1990
BH-96-59	7/11/1996
BH-96-60	7/11/1996
BH-96-61	7/11/1996
BH-96-62	7/11/1996
BH-96-63	7/15/1996
BH-96-64	7/15/1996
BH-96-65	7/19/1996
BH-96-66	9/10/1996
BH-96-66	9/10/1996
BH-96-67	9/10/1996
BH-96-67	9/10/1996
BH-96-68	10/1/1996
BH-96-69	10/1/1996
BH-96-70	10/1/1996
BH-96-71	10/1/1996
BH-96-72	9/30/1996
BH-96-73	9/30/1996
BH-96-74	9/30/1996
BH-96-75	9/24/1996
BH-97-01	3/4/1997
BH-97-02	3/3/1997
BH-97-03	2/26/1997
BH-97-04	2/26/1997
BH-97-05	3/4/1997
BH-97-08	2/25/1997
BH-98-CP-11	6/4/1998
MW-082	10/10/1990
MW-083	9/28/1990
MW-120	12/1/1992
MW-121	12/1/1992
MW-155	8/10/1993
MW-156	8/16/1993
MW-157	8/12/1993
MW-158	8/18/1993
MW-159	8/18/1993
MW-162	9/13/1993
MW-188	3/3/1997
MW-189	3/3/1997

Plant 2

ID	Date Installed
MW-007	11/25/1985
MW-007A	1/12/1994
MW-008	NA
MW-008A	1/7/1994
MW-009	11/21/1985
MW-00R2	NA
MW-010	1/23/1986
MW-011	11/29/1985
MW-012	1/28/1986
MW-013	12/30/1985
MW-014	12/29/1985
MW-015	12/29/1985
MW-015A	10/7/1989
MW-016	12/29/1985
MW-017	12/29/1985
MW-018	1/11/1986
MW-018A	10/6/1989
MW-019	1/11/1986
MW-020A	1/11/1986
MW-020B	1/11/1986
MW-020C	1/11/1986
MW-021A	1/12/1986
MW-021B	1/12/1986
MW-021C	1/12/1986
MW-022A	1/12/1986
MW-022B	1/12/1986
MW-023	1/23/1986
MW-025	1/24/1986
MW-027	1/18/1986
MW-028	3/23/1986
MW-029	1/28/1986
MW-031	2/1/1986
MW-032	1/31/1986
MW-033	1/28/1986
MW-034	1/28/1986
MW-036	2/5/1986
MW-037	1/28/1986
MW-038	1/29/1986
MW-039	2/8/1986
MW-048	3/21/1986
MW-049	3/22/1986
MW-050	3/22/1986
MW-051	3/23/1986
MW-052	3/23/1986
MW-053	7/22/1988
MW-054	7/22/1988
MW-102	11/1/1991
MW-103	11/4/1991
MW-106	11/5/1991
MW-107	11/6/1991
MW-117	5/3/1992
MW-118	7/7/1992
MW119A	7/8/1992
MW119B	7/9/1992
MW119C	7/10/1992
MW-142	12/27/1992
MW-143	12/27/1992
MW-144	12/28/1992
MW-145	12/28/1992
MW-146	12/27/1992
MW-147	12/20/1992
MW-148	12/20/1992
MW-149	12/19/1992
MW-150	12/22/1992
MW-151	12/26/1992
MW-172	11/6/1993
MW-173	11/7/1993
MW-174	11/3/1993
MW-176	1/7/1994
MW-177	1/11/1994
MW-196	5/20/1998
MW-197	1/27/2003
MW-198	1/27/2003
MW-199	6/24/2004
MW-200	6/8/2006
MW-201	6/8/2006
MW-202	6/8/2006
MW-203	6/8/2006

South Campus

ID	Date Installed
MW-001MK	11/21/1985
MW-002MK	11/26/1985
MW-003MK	11/29/1985
MW-024	1/23/1986
MW-024A	11/18/2002
MW-042	2/20/1986
MW-044	2/21/1986
MW-093	10/6/1990
MW-094	10/1/1990
MW-094R	1/29/2007
MW-095	10/2/1990
MW-095A	6/23/1996
MW-095R	1/29/2007
MW-135	2/2/1993
MW-136	2/3/1993
MW-138	4/23/1993
MW-139	4/22/1993
MW-140	4/22/1993
MW-141	4/23/1993
MW-175	11/8/1993
MW-193	7/25/1997
MW-194	7/28/1997
MW-204	1/30/2007
South Campus Extended	
MW-025	1/24/1986
MW-030	1/28/1986
MW-043	2/20/1986
MW-048	3/21/1986
MW-088	9/21/1990
MW-089	9/21/1990
MW-090	9/24/1990
MW-091	9/25/1990
MW-114	3/3/1992
MW-115	3/4/1992
MW-116	3/4/1992
MW-123	12/2/1992
MW-124	12/3/1992
MW-125	12/3/1992
MW-137	2/3/1993
MW-195	7/28/1997
BH-96-15	1/29/1996
BH-96-16	1/29/1996
BH-96-18	1/29/1996
BH-96-20	1/30/1996
BH-96-23	1/31/1996
BH-96-25	2/6/1996
BH-96-27	2/6/1996
BH-96-57	7/2/1996
BH-96-58	7/2/1996
BH-96-49	7/9/1996
BH-96-50	7/3/1996
BH-96-51	7/3/1996
BH-96-52	6/27/1996
BH-96-53	6/28/1996
BH-96-54	7/1/1996
BH-96-55	6/28/1996
BH-96-56	7/9/1996

500 Ramp

ID	Date Installed
B-001FL	7/5/1993
B-002FL	7/6/1993
B-003FL	7/2/1993
B-004FL	7/2/1993
B-005FL	7/2/1993
B-006FL	7/2/1993
B-007FL	7/2/1993
B-008FL	7/8/1993
B-009FL	9/15/1993
B-010FL	9/15/1993
B-011FL	9/15/1993
B-012FL	9/15/1993
BH-02-01	7/15/2002
BH-02-01S	NA
BH-02-02	7/8/2002
BH-02-02S	NA
BH-02-03	7/3/2002
BH-02-03S	NA
BH-02-04	7/9/2002
BH-02-04S	NA
BH-02-05	7/16/2002
BH-02-05S	NA
BH-02-06	7/5/2002
BH-02-06S	NA
BH-02-08	9/12/2002
BH-02-08S	NA
BH-02-09	9/18/2002
BH-02-09S	NA
BH-02-10	9/18/2002
BH-02-10S	NA
BH-03-02	2/17/2003
BH-03-03	2/13/2003
BH-03-04	2/13/2003
BH-03-05	2/12/2003
BH-03-06	2/12/2003
INJ-03-01	NA
INJ-03-02	NA
INJ-03-03	NA
INJ-03-04	NA
INJ-03-05	NA
INJ-03-06	NA
INJ-03-07	NA
INJ-03-08	NA
INJ-05-01	NA
INJ-05-02	NA
INJ-05-03	NA
INJ-05-04	NA
MW-037	1/28/1986
MW-097D	6/7/1991
MW-097S	6/11/1991
MW-099	5/30/1991
MW-100	5/31/1991
MW-166	9/15/1993
MW-167	9/14/1993
MW-168	9/14/1993
MW-169	9/22/1993
500 Ramp Extended	
BH-02-07	7/17/2002
BH-02-07	7/17/2002
BH-02-07	7/17/2002
BH-02-07S	NA
MW-098	5/29/1991
MW-101	6/12/1991

Other Areas

ID	Date Installed
D-9	
MW-117	5/3/1992
MW-185	7/15/1994
MW-186	7/14/1994
MW-187	7/29/1994
MAFB/Hangar 118F	
MW-038	1/29/1986
MW-178	4/7/1994
MW-179	4/18/1994
MW-180	7/11/1994
MW-181	7/13/1994
MW-182	7/12/1994
MW-205	3/5/2007
MW-206	3/7/2007
MW-207	3/7/2007
MW-208	3/16/2007
MW-209	3/8/2007
MW-210	3/9/2007
MW-211	7/2/2007
MW-212	7/3/2007
MW-213	7/5/2007
MW-214	7/6/2007
MW-215	7/9/2007
MW-216	7/18/2007
MW-217	7/19/2007
MW-218	10/8/2007
MW-219	10/9/2007
MW-220	10/10/2007
MW-221	10/16/2007
MW-222	10/12/2007
MW-223	10/18/2007
MW-224	11/21/2008
MW-225	11/20/2008
MW-226	11/20/2008
MAFB/Hangar 118F Extended	
MW-039	2/8/1986

Notes:
Installation dates based on spreadsheet titled REPORT-111709(1).xls WELL LIST FOR FEASIBILITY STUDY.xls provided by Boeing, with the exception of Reclamation area wells from "Reclamation MW TABLE Oct. 22, 2009.xls" and Plant 2 area wells from "Plant 2 MW TABLE FINAL Oct. 22, 2009.xls"
[orange] = Indicates well plugged and abandoned

Prepared by: ______
Checked by: ______
Reviewed by: ______

TABLE A-2
RECOVERY WELL NETWORK

BOEING FACILITY
WICHITA, KANSAS

Plant 1

Plant 1	Date Installed
RW-148	12/10/1993
RW-149	1/26/1990
RW-150	11/23/1993
RW-151	12/15/1993
RW-152	12/16/1993
RW-153	12/27/1993
RW-154	12/8/1993
RW-155	12/7/1993
RW-156	12/28/1993
RW-157	12/29/1993
RW-158	12/9/1993
RW-159	12/13/1993
RW-160	12/30/1993

Reclamation

Materials	Date Installed
RW-012	8/26/1987
RW-012A	1/25/1993
RW-013	8/26/1987
RW-013A	1/11/1991
RW-014	8/26/1987
RW-015	9/11/1987
RW-015A	9/10/1992
RW-016	8/27/1987
RW-017	8/27/1987
RW-018	8/28/1987
RW-018A	9/17/1992
RW-019	8/27/1987
RW-019A	9/22/1992
RW-020	8/28/1987
RW-045	9/2/1987
RW-046	9/2/1987
RW-046A	12/18/1992
RW-047	9/4/1987
RW-047A	10/7/1992
RW-101	9/11/1992
RW-102	9/10/1992
RW-103	9/11/1992
RW-104	9/14/1992
RW-105	9/11/1992
RW-106	9/22/1992
RW-107	9/11/1992
RW-108	9/11/1992
RW-142	6/16/1993
RW-143	6/14/1993
RW-144	6/15/1993
IWTP	
RW-053	2/13/1991
RW-054	1/18/1991
RW-055	2/13/1991
RW-056	2/14/1991
RW-057	3/13/1991
RW-092	8/6/1992
RW-093	8/7/1992
RW-094	8/11/1992
RW-095	8/13/1992
RW-096	8/14/1992

Plant 2

A6	Date Installed
RW-004AA	9/23/1992
RW-005	9/1/1987
RW-005A	9/9/1992
RW-006	9/1/1987
RW-006A	9/10/1992
RW-007	8/25/1987
RW-007A	9/9/1992
RW-008	8/24/1987
RW-008A	9/25/1992
RW-009	8/21/1987
RW-009A	9/25/1992
RW-010	9/2/1987
RW-010A	3/24/1990
RW-010AA	12/16/1992
RW-011	9/1/1987
RW-011A	12/17/1992
RW-026	8/17/1987
RW-027	8/19/1987
RW-027A	9/24/1992
RW-028	8/18/1987
RW-028A	9/25/1992
RW-029	8/20/1987
RW-030	8/28/1987
RW-031	9/2/1987
RW-049	9/10/1987
RW-049A	10/6/1992
RW-097	8/27/1992
RW-098	8/28/1992
RW-100	9/8/1992
RW-113	11/14/1992
RW-114	11/10/1992
RW-115	11/11/1992
RW-116	11/12/1992
RW-117	11/11/1992
RW-118	11/16/1992
RW-190	12/8/1998
RW-191	12/8/1998
RW-192	12/10/1998
RW-193	12/10/1998
Plant 2 - Leg 1	
RW-127	1/2/1993
RW-128	1/1/1993
RW-129	1/2/1993
RW-130	1/31/1993
RW-131	12/5/1992
RW-132	12/5/1992
RW-133	12/6/1992
Plant 2 - Leg 2	
RW-134	12/31/1992
RW-135	1/1/1993
RW-136	1/30/1993
RW-137	1/16/1993
RW-138	12/30/1992
RW-139	12/29/1992
RW-140	3/7/1993
RW-141	3/6/1993
Plant 2 - Leg 3	
RW-188	8/20/1998
RW-189	8/21/1998
Glickman	
RW-058	5/27/1992
RW-059	5/26/1992
RW-060	5/28/1992
RW-061	6/8/1992
RW-062	6/9/1992
RW-063	6/9/1992
RW-064	6/10/1992
RW-065	6/24/1992
RW-066	7/13/1992
RW-067	6/23/1992
RW-068	6/22/1992
RW-069	7/14/1992
RW-070	6/18/1992
RW-071	6/18/1992
RW-072	6/25/1992
RW-194	6/24/1999

South Campus

Warehouse O	Date Installed
RW-033	8/31/1987
RW-033A	6/20/1996
RW-034	9/3/1987
RW-035	9/1/1987
RW-035A	10/6/1992
RW-042	9/9/1987
RW-043	9/9/1987
RW-044	9/9/1987
RW-052	3/26/1990
RW-073	6/16/1992
RW-074	6/12/1992
RW-075	6/13/1992
RW-076	6/14/1992
RW-077	6/13/1992
RW-078	6/12/1992
RW-161	3/8/1994
RW-161R	11/1/2006
RW-162	3/10/1994
RW-162R	11/1/2006
RW-163	3/14/1994
RW-163R	11/1/2006
RW-164	3/15/1994
RW-164R	11/1/2006
IPB2	
RW-183	7/21/1997
RW-184	7/17/1997
RW-185	7/18/1997
RW-186	7/24/1997
RW-187	7/18/1997
Humane Society	
RW-040	9/4/1987
RW-079	8/3/1992
RW-080	7/2/1992
RW-081	7/6/1992
RW-082	7/7/1992
RW-083	7/8/1992
RW-084	7/9/1992
RW-085	7/30/1992
RW-086	7/29/1992
RW-087	7/28/1992
RW-088	7/27/1992
RW-089	7/23/1992
RW-090	7/21/1992
RW-091	7/20/1992
RW-119	12/3/1992
RW-120	12/7/1992
RW-121	12/8/1992
RW-122	12/9/1992
RW-123	12/9/1992
RW-124	12/8/1992
RW-125	12/10/1992
RW-126	12/10/1992

Other Systems

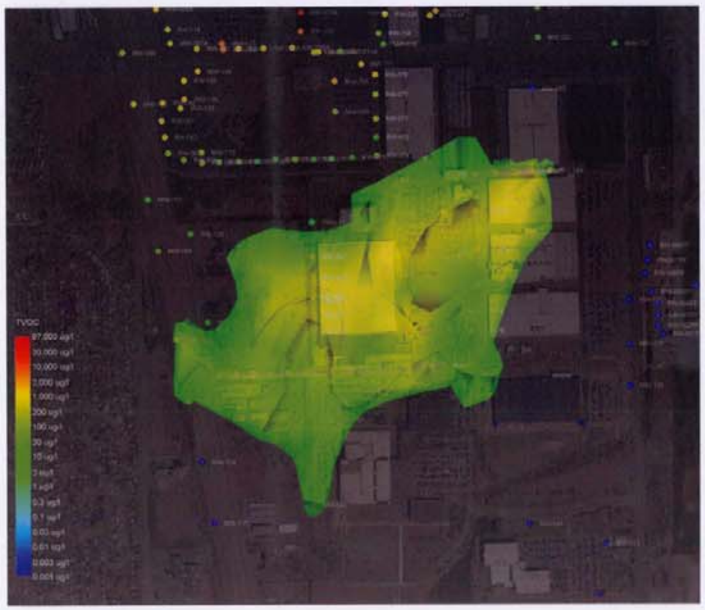
31st and Clifton	Date Installed
RW-201	5/6/2002
RW-202	5/7/2002
RW-203	5/8/2002
RW-204	5/10/2002
RW-205	5/15/2002
RW-206	5/13/2002
RW-207	5/16/2002
RW-208	5/16/2002
RW-209	7/2/2002
RW-210	6/18/2002
RW-211	6/13/2002
RW-212	6/11/2002
RW-213	5/29/2002
RW-214	5/28/2002
Activity Center	
RW-145	9/21/1993
RW-146	9/21/1993
RW-147	9/22/1993
D9	
RW-181	6/3/1997
RW-182	6/2/1997
Englewood	
RW-195	10/24/2002
RW-196	9/25/2002
RW-197	10/30/2002
RW-198	10/30/2002
RW-199	11/4/2002
RW-200	11/4/2002

Notes:
Installation dates based on spreadsheet titled "Recovery wells date installed etc .xlsx" provided by Boeing
[orange] = Indicates recovery well plugged and abandoned

Prepared by: ______
Checked by: ______
Reviewed by: ______

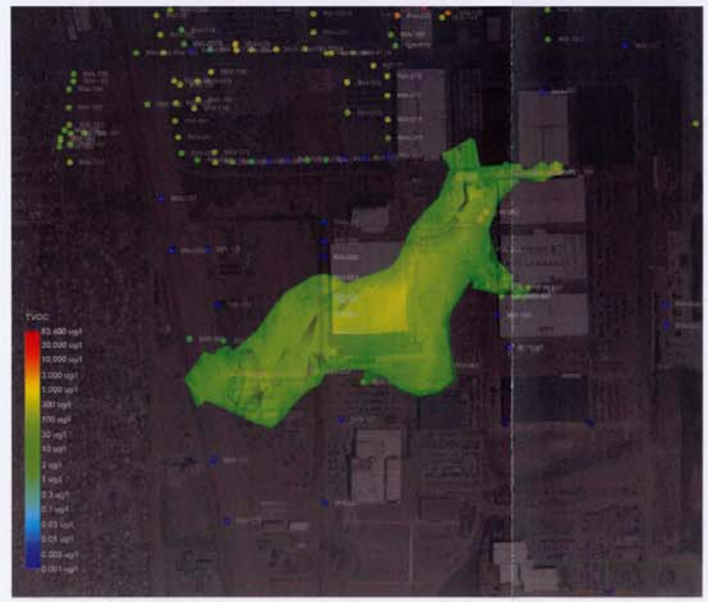
FIGURES

1995



ESTIMATED TVOC MASS = 125 KILOGRAMS (DISSOLVED PHASE)

2008



ESTIMATED TVOC MASS = 22 KILOGRAMS (DISSOLVED PHASE)

1,000 0 1,000
SCALE FEET

Golder Associates
Manchester, New Hampshire

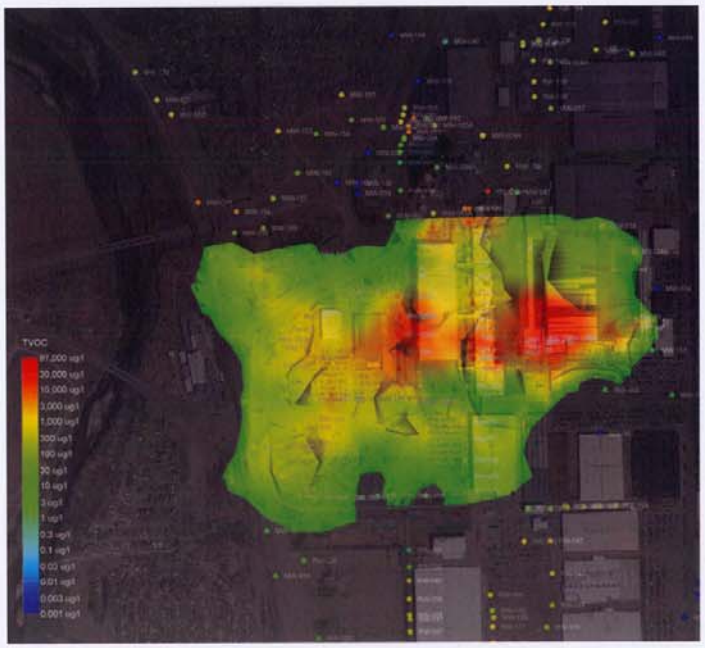
PROJECT
THE BOEING COMPANY
MODFLOW REPORT
WICHITA, KANSAS

TITLE
SOUTH CAMPUS
TVOC > 10 MICROGRAMS PER LITER

PROJECT No. 093-81501		
FILE No. 09381501-B001.A		
REV. 0	SCALE AS SHOWN	
DESIGN	BMW	12/17/09
CADD	PMD	12/17/09
CHECK		
REVIEW		

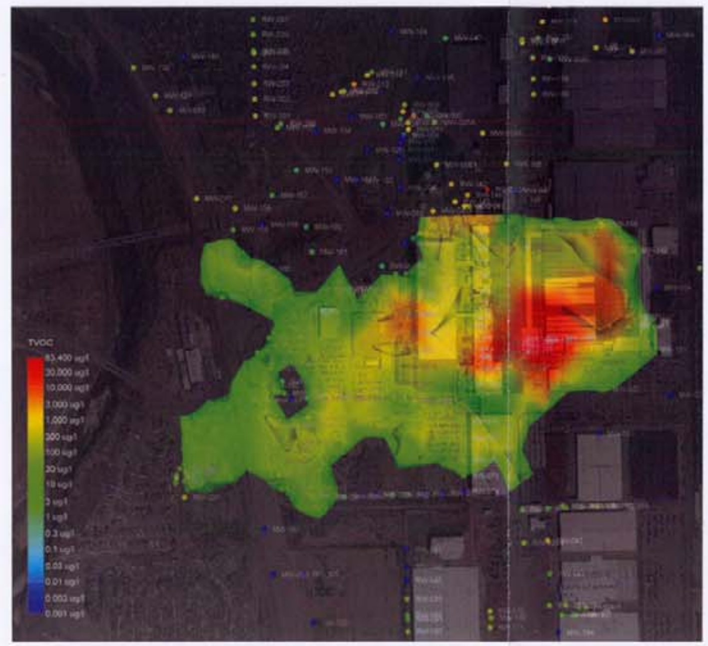
FIGURE A-1

1995



ESTIMATED TVOC MASS = 3,431 KILOGRAMS (DISSOLVED PHASE)

2008



ESTIMATED TVOC MASS = 2,476 KILOGRAMS (DISSOLVED PHASE)

1,150 0 1,150
SCALE FEET

Golder Associates
Manchester, New Hampshire

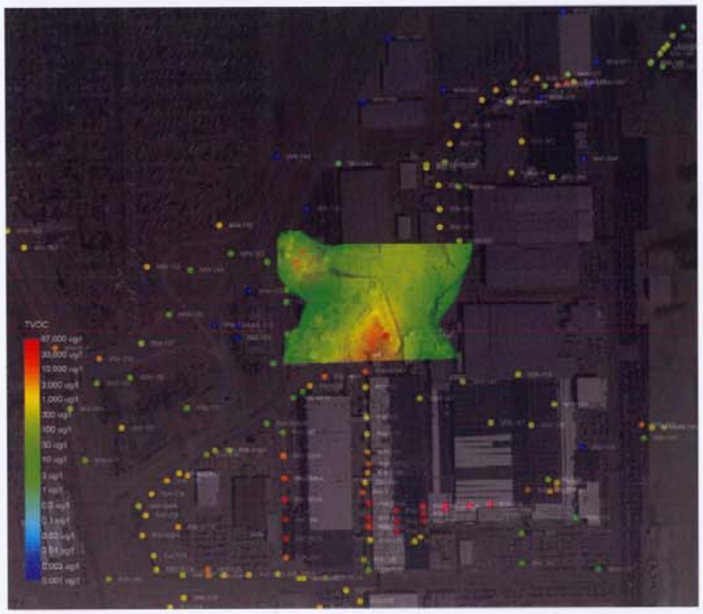
PROJECT
THE BOEING COMPANY
MODFLOW REPORT
WICHITA, KANSAS

TITLE
PLANT 2
TVOC > 10 MICROGRAMS PER LITER

PROJECT No. 093-81501		
FILE No. 09381501-B001.B		
REV. 0	SCALE AS SHOWN	
DESIGN	BMW	12/17/09
CADD	PMD	12/17/09
CHECK		
REVIEW		

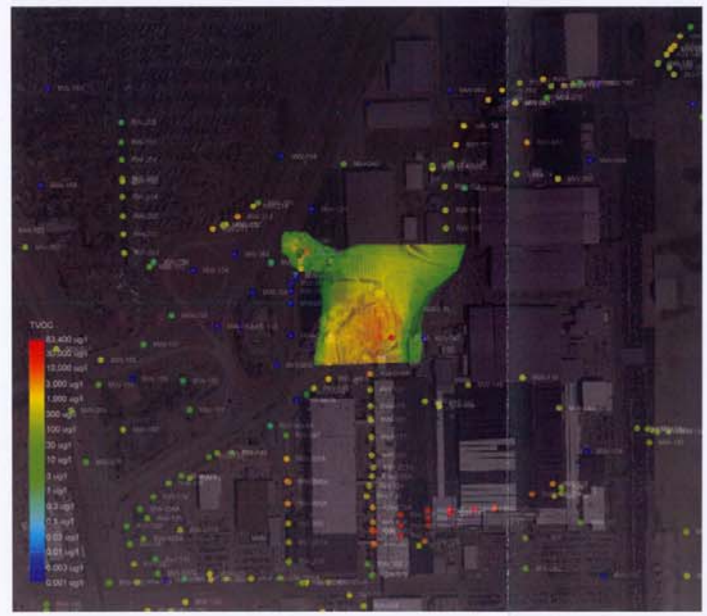
FIGURE A-2

1995



ESTIMATED TVOC MASS = 201 KILOGRAMS (DISSOLVED PHASE)

2008



ESTIMATED TVOC MASS = 112 KILOGRAMS (DISSOLVED PHASE)

1,000 0 1,000
SCALE FEET

Golder Associates
Manchester, New Hampshire

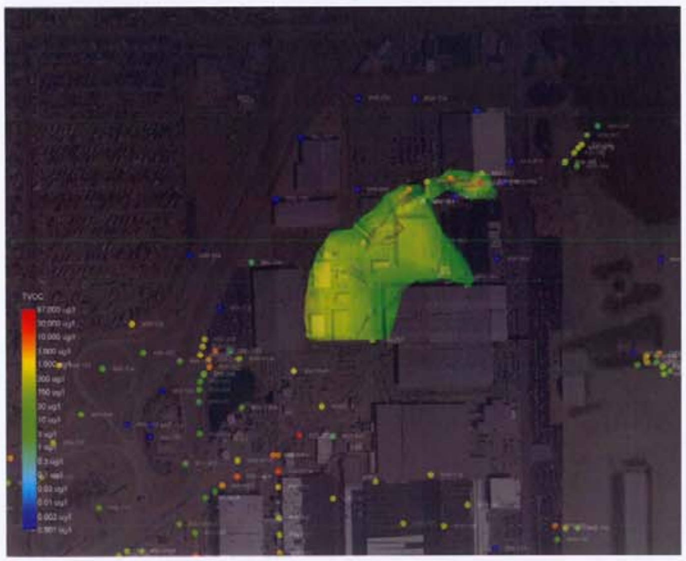
PROJECT
THE BOEING COMPANY
MODFLOW REPORT
WICHITA, KANSAS

TITLE
RECLAMATION
TVOC > 10 MICROGRAMS PER LITER

PROJECT No. 093-81501		
FILE No. 09381501-B001.C		
REV. 0	SCALE AS SHOWN	
DESIGN	BMW	12/17/09
CADD	PMD	12/17/09
CHECK		
REVIEW		

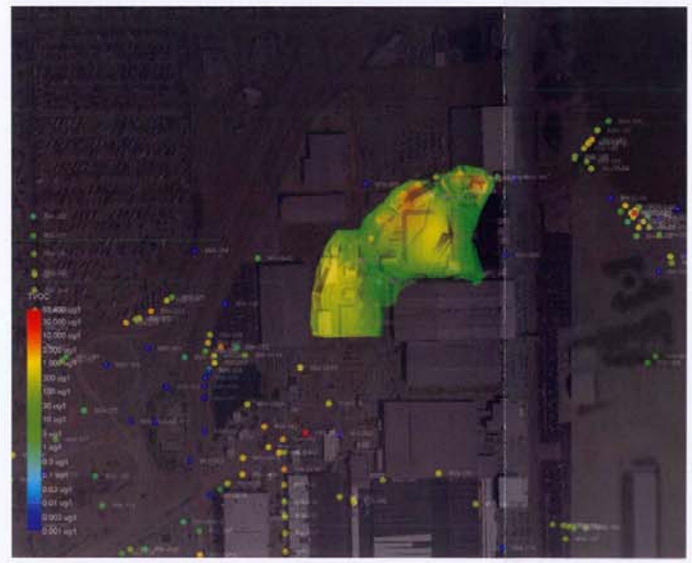
FIGURE A-3

1995



ESTIMATED TVOC MASS = 81 KILOGRAMS
(DISSOLVED PHASE)

2008



ESTIMATED TVOC MASS = 62 KILOGRAMS
(DISSOLVED PHASE)

1,000 0 1,000
SCALE FEET

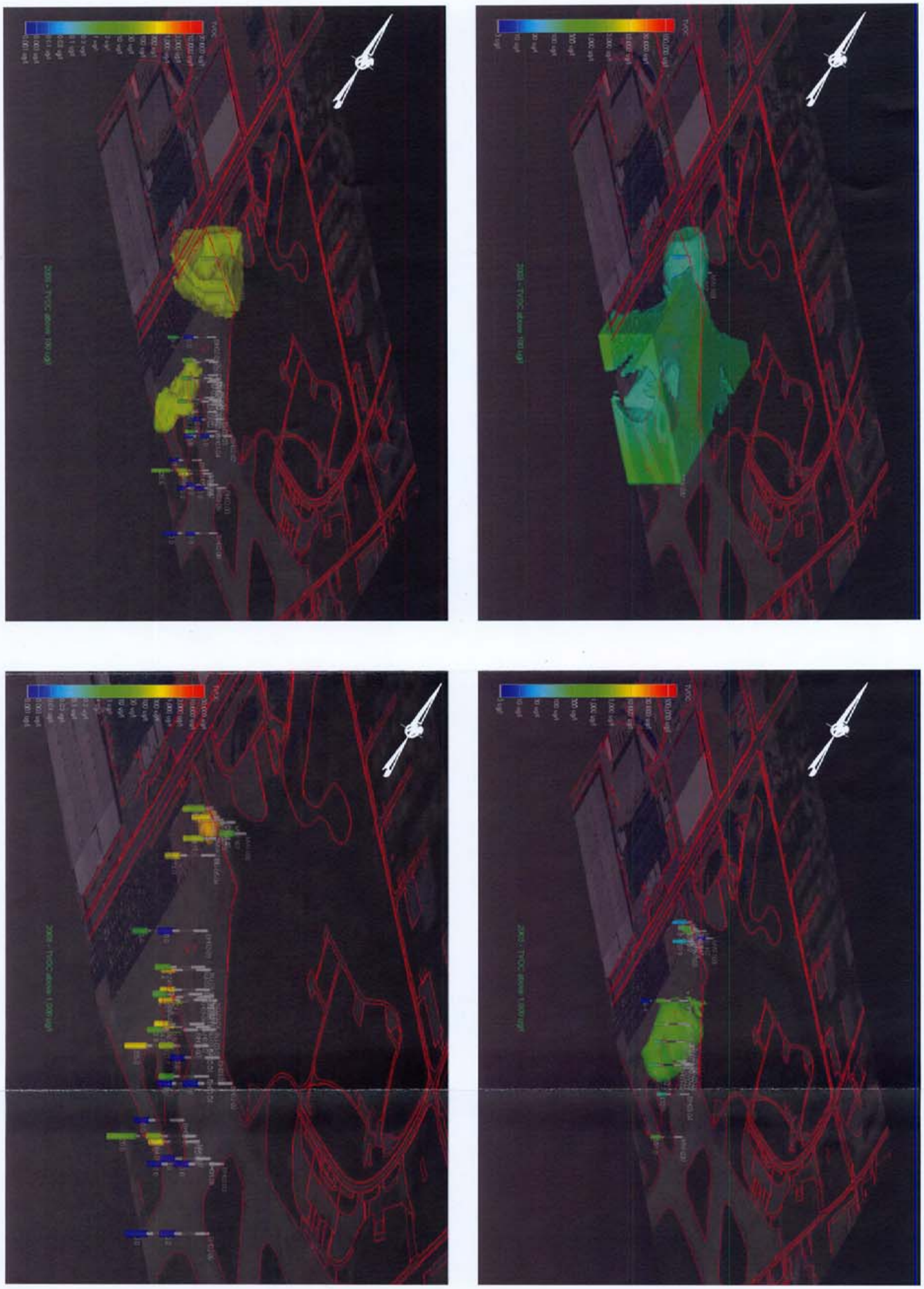
Golder Associates
Manchester, New Hampshire

PROJECT
THE BOEING COMPANY
MODFLOW REPORT
WICHITA, KANSAS

TITLE
PLANT 1
TVOC > 10 MICROGRAMS PER LITER

PROJECT No. 093-81501		
FILE No. 09381501-B001.D		
REV. 0	SCALE AS SHOWN	
DESIGN	BMW	12/17/09
CADD	PMD	12/17/09
CHECK		
REVIEW		

FIGURE A-4



PROJECT No.	093-81501
FILE No.	0938150I-B001.E
REV. 0	SCALE AS SHOWN
DESIGN	BMW 12/17/09
CADD	PMD 12/17/09
CHECK	
REVIEW	

FIGURE A-5

TITLE

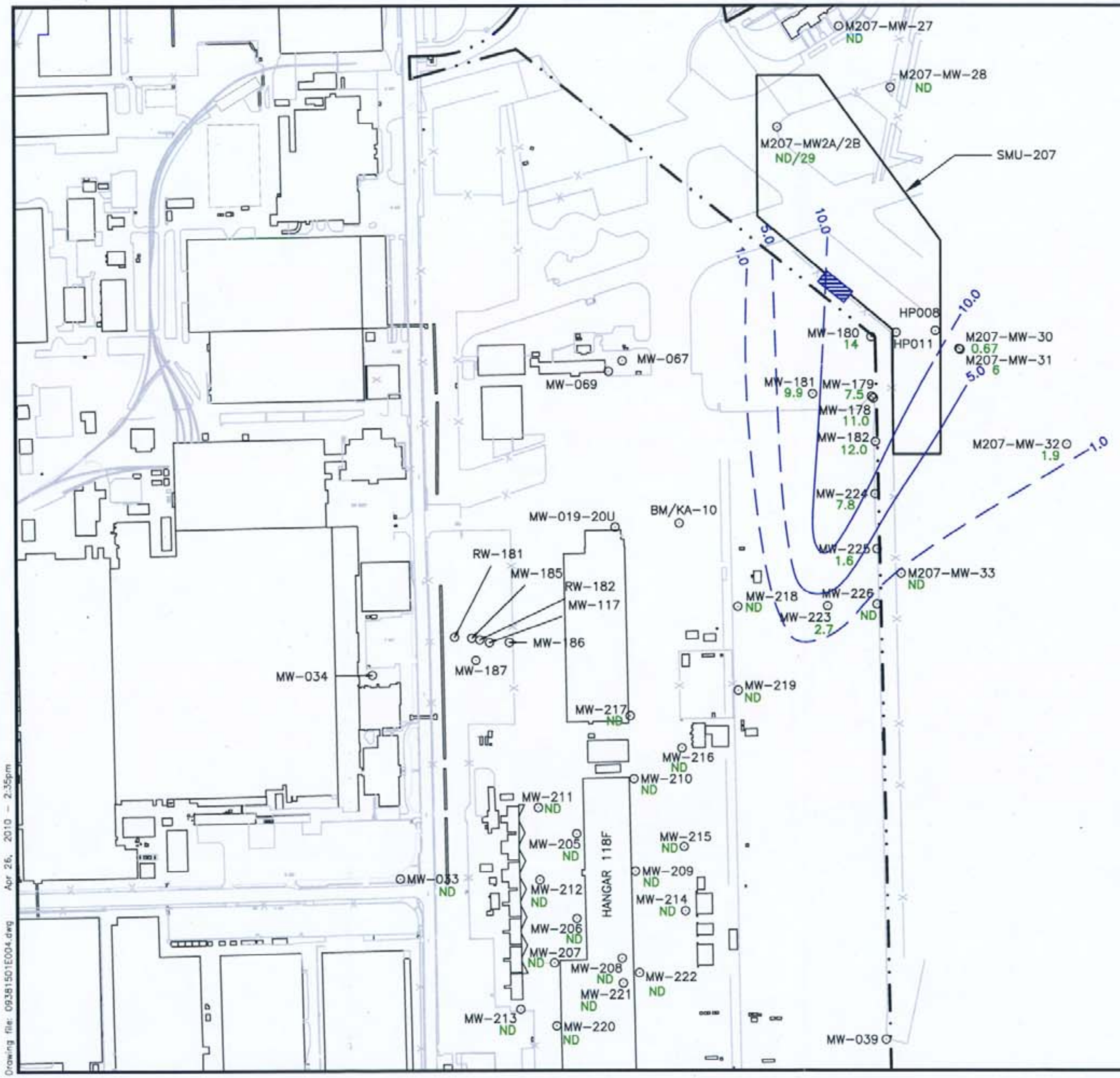
500 RAMP

PROJECT

THE BOEING COMPANY
MODFLOW REPORT
WICHITA, KANSAS

Golder Associates
Manchester, New Hampshire

Drawing file: 09381501E004.dwg Apr 26, 2010 - 2:35pm



LEGEND

○ MW-215	MONITORING WELL LOCATIONS
7.5	2008 CARBON TETRACHLORIDE CONCENTRATION (PPB)
— · · —	APPROXIMATE BOEING/MCCONNELL PROPERTY BOUNDARY
— 1.0 —	INTERPRETED 2008 CARBON TETRACHLORIDE ISOCONCENTRATION CONTOURS (DASHED WHERE INFERRED)

NOTE

1. SITE FEATURES ARE APPROXIMATE.
2. MW-179 AND MW-178 REPLACED MW-038 IN 1994.

REFERENCE

1. BASE MAP FROM CADD FILE TITLED "NEWBASEMAP2.DWG", PROVIDED BY THE BOEING COMPANY.
2. BOEING WELL LOCATIONS BASED ON COORDINATES FROM "WELLS_WATERLOO(1) UPDATED BY TJH.XLS", PROVIDED BY FRANZ ENVIRONMENTAL INC.
3. SWMU 207 BOUNDARY BASED ON FIGURE 8.1 "GROUNDWATER CONTOUR MAP INVESTIGATION (2007)" PREPARED BY HDR ENGINEERING INC. DATED JULY 2008.
4. MCCONNELL WELL LOCATIONS BASED ON COORDINATES FROM "MCCONNELAFB_STRATA_07_WITHXYS.XLS", PROVIDED BY FRANZ ENVIRONMENTAL INC.
5. ANALYTICAL DATA FOR BOEING PROPERTY WELLS BASED ON AUGUST-SEPTEMBER 2008 MONITORING DATA PROVIDED BY THE BOEING COMPANY.
6. ANALYTICAL DATA FOR MCCONNELL PROPERTY WELLS BASED ON MAY 2008 MONITORING DATA FROM TABLE 3 "VOC CONCENTRATIONS IN MAFB MONITORING WELLS" REFERENCED FROM DRAFT SOLID WASTE MANAGEMENT UNIT 207 SUPPLEMENTAL RCRA FACILITY INVESTIGATION REPORT DATED SEPTEMBER 2008

500 0 500
SCALE FEET

Golder Associates
Manchester, New Hampshire

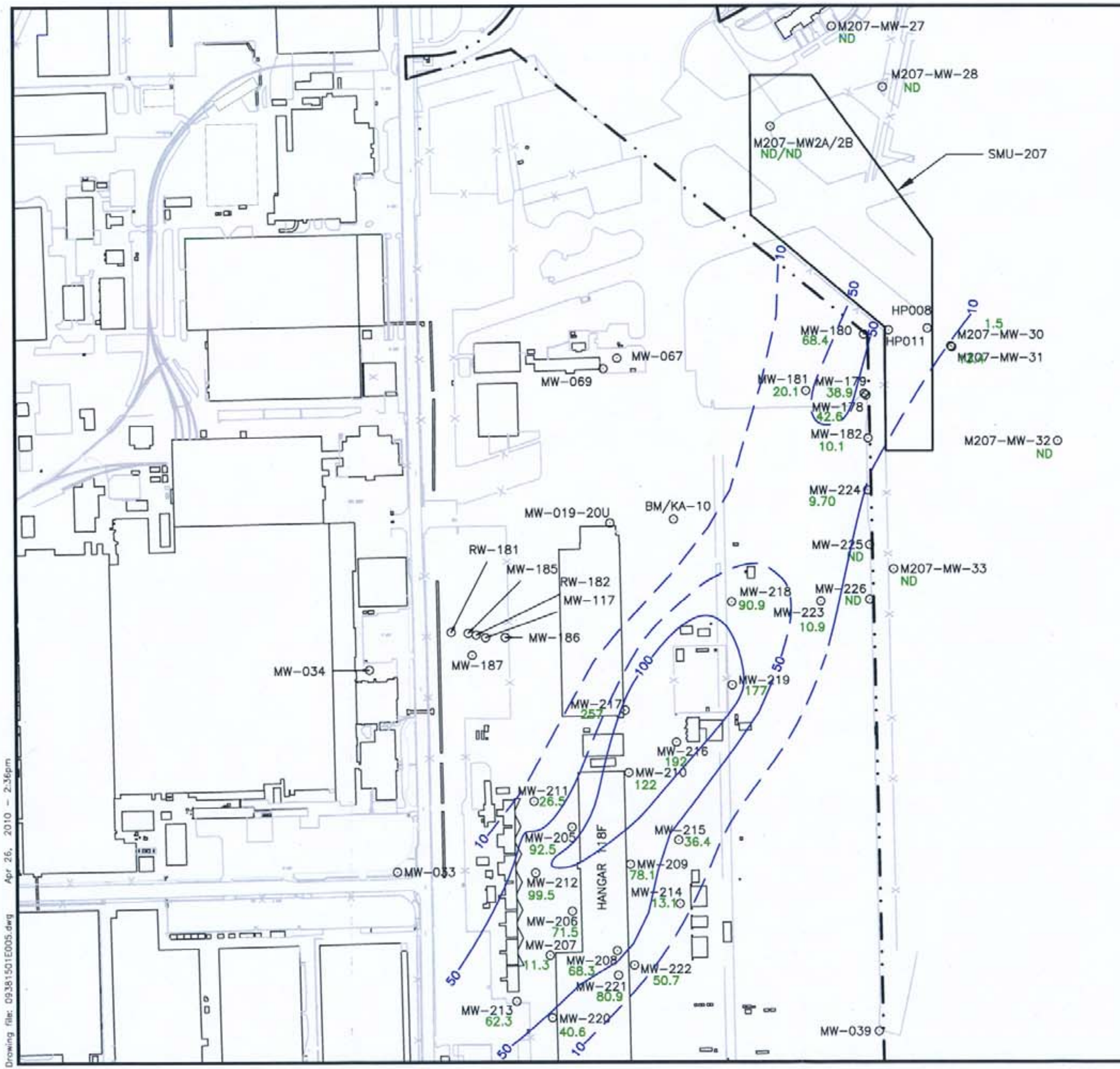
PROJECT
THE BOEING COMPANY
BOEING AND MCCONNELL
AIR FORCE BASE
WICHITA, KANSAS

TITLE
MAFB CARBON TETRACHLORIDE ISOCONCENTRATION MAP

PROJECT No.	093-87501	
FILE No.	09387501E004	
REV. 0	SCALE	AS SHOWN
DESIGN	RWB	01/09/10
CADD	MPB	01/09/10
CHECK		
REVIEW		

FIGURE A-6

Drawing file: 09381501E005.dwg Apr 26, 2010 - 2:36pm



LEGEND

O MW-215	MONITORING WELL LOCATIONS
7.5	2008 TRICHLOROETHYLENE CONCENTRATION (PPB)
— · · —	APPROXIMATE BOEING/MCCONNELL PROPERTY BOUNDARY
— 1.0 —	INTERPRETED 2008 TRICHLOROETHYLENE ISOCONCENTRATION CONTOURS (DASHED WHERE INFERRED)

NOTE

1. SITE FEATURES ARE APPROXIMATE.
2. MW-179 AND MW-178 REPLACED MW-038 IN 1994.

REFERENCE

1. BASE MAP FROM CADD FILE TITLED "NEWBASEMAP2.DWG", PROVIDED BY THE BOEING COMPANY.
2. BOEING WELL LOCATIONS BASED ON COORDINATES FROM "WELLS_WATERLOO(1) UPDATED BY TJH.XLS", PROVIDED BY FRANZ ENVIRONMENTAL INC.
3. SWMU 207 BOUNDARY BASED ON FIGURE 8.1 "GROUNDWATER CONTOUR MAP INVESTIGATION (2007)" PREPARED BY HDR ENGINEERING INC. DATED JULY 2008.
4. MCCONNELL WELL LOCATIONS BASED ON COORDINATES FROM "MCCONNELAFB_STRATA_07_WITHXYS.XLS", PROVIDED BY FRANZ ENVIRONMENTAL INC.
5. ANALYTICAL DATA FOR BOEING PROPERTY WELLS BASED ON AUGUST-SEPTEMBER 2008 MONITORING DATA PROVIDED BY THE BOEING COMPANY.
6. ANALYTICAL DATA FOR MCCONNELL PROPERTY WELLS BASED ON MAY 2008 MONITORING DATA FROM TABLE 3 "VOC CONCENTRATIONS IN MAFB MONITORING WELLS" REFERENCED FROM DRAFT SOLID WASTE MANAGEMENT UNIT 207 SUPPLEMENTAL RCRA FACILITY INVESTIGATION REPORT DATED SEPTEMBER 2008

500 0 500
SCALE FEET

Golder Associates
Manchester, New Hampshire

PROJECT
THE BOEING COMPANY
BOEING AND MCCONNELL
AIR FORCE BASE
WICHITA, KANSAS

TITLE
MAFB TRICHLOROETHENE ISOCONCENTRATION MAP

PROJECT No. 093-87501		
FILE No. 09387501E005		
REV. 0	SCALE AS SHOWN	
DESIGN	RWB	01/08/10
CADD	MPB	01/08/10
CHECK		
REVIEW		

FIGURE A-7