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Pinellas Environmental Restoration Project

Building 100 Area Corrective Measures Study Report Addendum

July 2006

U.S. Department of Energy

Office of Legacy Management

Work Performed Under DOE Contract No. DE-AC01-02GJ79491
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Work Performed by S.M. Stoller Corporation under DOE Contract No. DE–AC01–02GJ79491
for the U.S. Department of Energy Office of Legacy Management, Grand Junction, Colorado

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Appendix A Time-Concentration Plots for Selected Building 100 Area Wells

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Acronyms and Abbreviations

bls	below land surface
cDCE	*cis*-1,2-dichloroethene
CMIP	Corrective Measures Implementation Plan
CMS	Corrective Measures Study
COPC	contaminants of potential concern
DCE	dichloroethene
DHC	*Dehalococcoides ethenogenes*
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FDEP	Florida Department of Environmental Protection
FRTR	Federal Remediation Technologies Roundtable
ft	feet
Hawthorn	Hawthorn Formation
HSWA	Hazardous and Solid Waste Amendments
IC	institutional control
MCL	maximum contaminant level
µg/L	micrograms per liter
NAPL	non-aqueous phase liquids
RBCA	Risk-Based Corrective Action
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RMO	Risk Management Option
SWMU	Solid Waste Management Unit
STAR Center	Young-Rainey Science, Technology, and Research Center
TCE	trichloroethene
tDCE	*trans*-1,2-dichloroethene
VC	vinyl chloride
VOCs	volatile organic compounds

End of current text

Executive Summary

Remediation alternatives for the Building 100 Area are evaluated in this document. The evaluation demonstrates that no active remediation system, including the current system, would be effective at meeting the remediation goals given the constraints that current site use and physical limitations have on adequately characterizing, designing, and implementing an active remedial alternative from outside the building.

A subsequent evaluation of risk indicated that current site conditions are adequately protective of human health and the environment. No complete exposure pathways exist, and the contaminant plume is stable and confined to site boundaries. On the basis of this analysis, No Further Action with Controls is the only viable alternative for the Building 100 Area. DOE proposes that institutional controls be placed on the site property to prevent inappropriate ground water use and that maximum contaminant levels for site-related contaminants be applied as ground water cleanup goals outside the institutional control boundary. This approach is consistent with EPA's RCRA ground water policy where containment of the plume is the final ground water goal rather than meeting cleanup levels throughout contaminated ground water.

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1.0 Introduction

The Young-Rainey Science, Technology, and Research Center (STAR Center) is a former U.S. Department of Energy (DOE) facility located in Largo, Florida. Two of the remaining four active Solid Waste Management Units (SWMUs) at the STAR Center are PIN06, the Old Drum Storage Site, and PIN12, the Industrial Drain Leaks-Building 100 Area (Figure 1). These two SWMUs are being remediated together because they are adjacent and have similar contaminants. Together, these two SWMUs are referred to as the Building 100 Area.

Several years have passed since the Building 100 Area Corrective Measures Study (CMS) Report (DOE 1994), the Corrective Measures Implementation Plan (CMIP) (DOE 1996a), and the CMIP Addendum (DOE 1998) were written. During this time, several changes have occurred, as listed below.

- Property ownership has transferred from DOE to Pinellas County.
- Site-specific information, such as water quality data, has been updated, and changes in ground water contaminant distribution and plume area have been observed.
- The potential for the presence of non-aqueous phase liquids (NAPLs) has been identified.
- New and updated information concerning remediation technologies has become available.
- The regulatory setting has changed with the recent promulgation by the Florida Department of Environmental Protection (FDEP) of Global Risk-Based Corrective Action (RBCA) rules.
- Remediation schedule and priorities have been revised.

Because of these changes, many of the conclusions in the CMS Report, the CMIP, and the CMIP Addendum have become outdated. Therefore, this CMS Report Addendum has been written to update site conditions, discuss the regulatory framework, and re-evaluate active remediation alternatives.

1.1 Report Organization

Section 1 includes the introduction, purpose, regulatory framework, and Building 100 Area background information. Section 2 is a description of current site conditions, including hydrogeology, a description of the site contaminants of potential concern (COPCs), an evaluation of the nature and extent of contamination at the site, the conceptual site model, and an evaluation of potential exposure pathways. Section 3 describes the remediation objectives. Section 4 identifies the active remediation alternatives, and Section 5 evaluates the risk management options in light of the current regulatory framework. Section 6 presents the conclusions and recommended alternative. Section 7 lists the references used during writing of this document. The references in Section 7 are called out in the body of the document by listing, in parentheses, first the author of the referenced document and then the date of publication of the document, e.g. (DOE 1996). All figures are located after Section 7. Small tables are included within the text, but large tables are located toward the end of the document, after the figures.

1.2 Purpose

The purpose of this document is to review remediation alternatives, analyze and screen the available alternatives for applicability at the Building 100 Area, and recommend the alternative that can accomplish the remediation objectives, given the existing constraints and limitations associated with the site.

Ground water recovery with surface treatment at the Building 100 Area began in July 1995, has operated nearly continuously since that time, and is ongoing. During this time, over 22,000,000 gallons of ground water has been recovered, containing over 2,200 pounds of contaminants. In addition, naturally occurring biodegradation processes have decreased concentrations of some contaminants. However, environmental restoration has been limited by site infrastructure.

Specifically, an 11-acre building, occupied by 16 tenant companies that employ over 1,000 workers, covers the site. Buildings, paved roads, and parking lots cover the adjacent surrounding area, comprising another 46 acres of ground cover (Figure 2) on the 97-acre site. This mature infrastructure has precluded conventional contaminant characterization and delineation and remains a significant obstacle to implementation of proven remediation technologies.

Because of the severe limitations on the ability to implement available active remediation alternatives, this document also addresses long-term general remedial action alternatives in light of updated site information. These alternatives include administrative or institutional actions that can also achieve remediation objectives.

1.3 Regulatory Framework

Cleanup at the STAR Center is being conducted in accordance with requirements of the Resource Conservation and Recovery Act (RCRA). In 1987, the U.S. Environmental Protection Agency (EPA) performed a RCRA Facility Assessment (EPA 1988) to gather information on potential releases of hazardous materials. As a result, EPA issued a Hazardous and Solid Waste Amendments (HSWA) permit to DOE in February 1990, requiring DOE to investigate and perform remediation activities in areas contaminated by hazardous materials generated through DOE operations. In November 2000, the State of Florida received HSWA authorization from EPA. FDEP issued a new HSWA permit to DOE in January 2002. The current permit is due for renewal in January 2007. Characterization studies and other activities discussed in Section 1.4 were conducted in accordance with the HSWA permit that existed at the time.

The current HSWA permit indicates that ground water is the potentially affected medium of concern for the remaining SWMUs at the STAR Center, including the Building 100 Area. The permit also specifies that media cleanup criteria proposed in a CMS must be either background, promulgated federal and state standards, state cleanup criteria, or alternate risk-derived target cleanup levels. The CMS previously prepared for the Building 100 Area (DOE 1994) specified maximum contaminant levels (MCLs) as the proposed cleanup levels for Building 100 ground water. However, since that time, additional guidance and regulations have been issued by the State of Florida and EPA with regard to RCRA corrective action policy (EPA 2004), institutional controls (ICs) (FDEP 2004), and risk-based cleanup approaches (FDEP 2005). In this CMS

addendum, applicable cleanup levels for the Building 100 Area ground water are reevaluated based on a consideration of more recent guidance and regulations as well as the performance of the remediation system to date (see further discussion in Section 5).

1.4 Building 100 Area Background

The Pinellas Plant was constructed in the mid-1950s and primarily manufactured neutron generators for nuclear weapons. Additional products manufactured at the plant included radioisotope-powered thermoelectric generators, thermal batteries, specialty capacitors, crystal resonators, neutron detectors, lightning arrester connectors, and vacuum switch tubes. Operation of the plant ceased in 1995. Thereafter, site activities were predominantly related to environmental restoration. On March 17, 1995, DOE sold the Pinellas Plant to the Pinellas County Industry Council. The sales contract included clauses to ensure continued cleanup of the site by DOE. On July 1, 1999, the Pinellas County Industry Council was dissolved, and ownership of the STAR Center changed to the Pinellas County government. The former Pinellas Plant became the Pinellas Science, Technology, and Research Center, and subsequently the Young-Rainey STAR Center.

1.4.1 Building 100 Industrial Drain Leaks

Building 100 is the most notable feature of the STAR Center, covering approximately 11 acres in the southeastern corner of the STAR Center (Figure 1). This structure housed the DOE Pinellas Area Office and the majority of former laboratory and production facilities located at the site. A number of other former and current structures functioning as storage, utility, conveyance, and testing facilities are located around Building 100 and throughout the STAR Center (Figure 2). One of the former structures, the Old Drum Storage Site, is discussed in Section 1.4.2.

The need for remediation of environmental contamination at the Building 100 Area was first identified during investigations conducted under the DOE Comprehensive Environmental Assessment and Response Program. The *Phase I: Installation Assessment Pinellas Plant* (DOE 1987b) identified the Old Drum Storage Site and the Industrial Drain Leaks at Building 100 as areas potentially requiring remediation based on past waste storage and handling activities.

SWMU PIN12 (Industrial Drain Leaks) consists of the liquid waste drain system that served Building 100. Four individual drainage systems were present within and beneath the building: health physics, chemical, sanitary, and storm systems. During the mid to late 1970s, drain lines associated with Building 100 deteriorated so that several leaks occurred under the building (DOE 1987a, 1987b). The drain lines were repaired when the leaks were discovered, but an undetermined amount of waste escaped to the soil. These reports (DOE 1987a, 1987b) do not specify which drain systems leaked, or where the leaks occurred.

The health physics drain system in Building 100 was originally composed of two piping systems: health physics (standard) for fluids that were used in production processes involving the exclusive use of tritium, and health physics (chemical) for fluids that had potentially been in contact with either tritium or hazardous wastes (DOE 1991) (Figures 3 and 4). These two piping systems were later tied together during building additions. The liquid within the health physics system was gravity-drained to a manhole near the southwest corner of Building 100, then

continued to a lift station that pumped the liquid to one of three holding tanks. The composition of the health physics waste stream was primarily deionized water; however, any fluid that may have been contaminated with tritium entered the health physics system. These fluids may have included photographic developers and fixatives, cleaners, and acids (EMC 1989).

The chemical drain system in Building 100 (Figure 4) disposed of liquids such as acids, caustics, rinses, or other liquids that were not purely sanitary, such as condensate from air-handling units (DOE 1991). In general, the chemical drains within Building 100 flowed to the east to be pumped west of the building to the main lift station. The chemical waste stream was generated by rinsing and diluting procedures in the laboratories and from condensate drains in the air-handling units. The composition of the chemical waste stream was primarily deionized water, photographic developers and fixatives, cleaners, and acids in dilute concentrations.

An investigation to determine the existing conditions of the Building 100 waste drainage systems was conducted by EMC Engineers, Inc. in 1989 (EMC 1989). All four drainage systems were investigated, including verification of system routing and the condition of underground and aboveground piping and ancillary equipment. Visual inspection, dye test tracing, excavation, ultrasonic testing, in-line video observation, and employee interviews were conducted. The investigation concluded that a portion of the health physics and chemical waste systems should be replaced, and that five possible leaks were identified as needing further investigation. Another important conclusion was that there were possible additional drain leaks beneath Building 100 that could contribute to the existing contaminant plume identified along the northwest corner of Building 100, or that could cause additional contaminant plumes at other locations beneath Building 100. Pinellas Plant facility personnel repaired the five identified drain leaks in Building 100 during maintenance operations (DOE 1994). Subsequently, the health physics and chemical drain systems were flushed, grouted, and abandoned, and some of the chemical drain systems were replaced by an aboveground system that currently is in use (DOE 1997).

1.4.2 Old Drum Storage Site

The Old Drum Storage Site (SWMU PIN06) is the former location of a concrete storage pad, equipped with a drain and containment system, used to store hazardous waste, including methylene chloride, ignitable liquids, arsenic, and calcium chromate solids (DOE 1987a). The concrete pad was located near the northwest corner of Building 100 (Figure 5). Empty drums containing residual waste solvents were also stored in this area (DOE 1987b). The pad was removed in October 1983 in accordance with an FDEP closure permit (DOE 1987a); a closure report was submitted to FDEP in August 1986 (DOE 1986).

Employees interviewed indicated that, before 1960, drums were stored in an open area that is now under the northwest corner of Building 100 (DOE 1987b). These drums contained Epon 828 resin as bottoms (the small amount left in a drum after it has been used). According to employee interviews, in some cases drums were tipped over to drain the remaining contents. The resin itself is not a contaminant, but other potential contaminants may have been contained in the drums. This site may not have been fully cleaned up before the expansion of Building 100 covered the area.

1.4.3 Building 100 Area Documentation and Remediation History

This section summarizes the remediation history and also reviews the regulatory documentation for the Building 100 Area. This information is summarized graphically in Figure 6.

A RCRA Facility Investigation (RFI) was conducted in 1991 at the Pinellas Plant to fulfill requirements of the HSWA permit, and an RFI Report was produced (DOE 1991). A subsequent RFI Report Addendum was completed in March 1992. Based on the findings in these two documents, in accordance with the HSWA permit, EPA notified DOE of the requirement for a CMS for the Old Drum Storage Site and the Industrial Drain Leaks - Building 100 SWMUs.

The CMS Report for the Building 100 Industrial Drain Leaks and Old Drum Storage Site (DOE 1994) proposed remediation of these two SWMUs together (collectively referred to as the Building 100 Area). The report was submitted to EPA and subsequently approved on June 9, 1994. FDEP approved the CMS Report on January 18, 1995.

Three potential corrective measures actions were identified from the screening process in the CMS Report:

- Pump-and-treat with an existing air stripping system;
- Pump-and-treat with UV/oxidation; and
- Pump-and-dispose to the Pinellas County publicly owned treatment works.

The CMS Report concluded that pump-and-treat with the existing air stripping system was the preferred corrective measure for the Building 100 Area. This conclusion was based on shallow monitoring well data that suggested contamination was confined to shallow ground water at the northwest corner of the building. However, that characterization was incomplete. Two recovery wells were installed at the northwest corner of the building in 1995. The CMIP (DOE 1996a) describes the installation of the wells and the operations and monitoring plan.

These recovery wells, PIN12−RW01 and −RW02, extracted ground water and pumped the water through secondary containment piping to the Northeast Site treatment system for pretreatment, air stripping, and discharge to the STAR Center industrial wastewater neutralization facility prior to transfer to the publicly owned treatment works. The Northeast Site treatment system was decommissioned in April 2004, so a smaller air stripper treatment system was installed at the Northeast Site to treat the ground water recovered via the two Building 100 Area recovery wells. Operation of these recovery wells and treatment system is ongoing.

Subsequent to recovery well installation, additional investigations were conducted by installing monitoring wells at multiple depths both outside the building and through the floor of the building. These investigations are summarized in the Building 100 Subsurface Investigation (DOE 1996b) and the Building 100 Area Data Report (DOE 1996c). Results of these investigations indicated that significant contaminant concentrations were present at medium and deep depths under the building, and that low levels of contamination were present at the south and east sides of the building. The Building 100 Area Data Report (DOE 1996c) made the following recommendations:

- Continue operating the two recovery wells installed under the CMS/CMIP,
- Conduct additional characterization under the building and east of the building,

- Perform additional contaminant transport modeling, and
- Evaluate the potential for occurrence of dense NAPLs.

The recommendations were addressed in the Building 100 Area CMIP Addendum (DOE 1998). Several different pumping scenarios were modeled, and it was recommended that two additional recovery wells at the southeast corner of Building 100 be installed as the supplemental alternative.

In June 1998, FDEP responded to the CMIP Addendum with comments regarding the possible presence of a more permeable zone near the base of the surficial aquifer, the apparent deepening of the surficial deposits to the southeast of Building 100, and the suggestion of additional deep wells into the Floridan aquifer. FDEP went on to state that until an additional hydrogeologic assessment is completed, installation of the new recovery systems should be delayed.

DOE provided a response to FDEP's comments in a December 1998 letter. The content of this letter was of sufficient detail to satisfy FDEP with one exception: the need for additional monitoring wells installed into the Floridan aquifer. In April 1999, DOE proposed, and FDEP approved, two Floridan aquifer well locations adjacent to Building 100. The two Floridan aquifer wells (PIN12−0527 and –0528) were installed in August 1999 and May 2000. The location of these two wells is shown on Figure 7.

In October 1999, DOE sent FDEP a letter that contained a proposal to evaluate the potential installation of a permeable reactive barrier wall and further evaluate other treatment technologies for remediation of the contaminant plume beneath Building 100. Specifically, DOE proposed to evaluate the results from the 4.5 Acre Site biosparge system to see if this type of remediation might be effective beneath Building 100. FDEP approved DOE's recommendation in a November 1999 letter.

The first part of the DOE proposal was accomplished in December 1999 with the completion of a bench-scale treatability report for treatment of dissolved volatile organic compounds (VOCs) present in ground water at the Building 100 Area. The results from this study indicated that a reactive wall would degrade the chlorinated VOCs to MCLs using iron metal as the reactive medium. However, this reactive wall would only treat very low concentrations of contaminants near the property boundary and would not treat contaminants under the building. The applicability of a permeable reactive barrier wall is evaluated further in Section 5.

Operation of the 4.5 Acre Site biosparge system was discontinued in May 2003. An evaluation of the system had shown that it was not effective at treating the remaining low levels of contamination. Based on this lack of effectiveness at the 4.5 Acre Site, it was determined that biosparging likely would not be effective at the Building 100 Area.

In summary, the original pump-and-treat system that was installed based on an incomplete characterization currently continues operation. The two additional recovery wells recommended in the CMIP Addendum were not installed, and no additional remediation components or systems have been installed.

1.4.4 Building 100 Area Infrastructure

A significant amount of infrastructure exists in the Building 100 Area (Figure 8). This includes subsurface utility lines such as water, compressed air, electrical, sewer, and communications, as well as irrigation piping and the abandoned chemical and health/physics lines under the building. Surface infrastructure includes roadways, parking lots, sidewalks, and several other buildings, including the day care center on the east side of the building. This land use is expected to continue into the foreseeable future given development pressures in the area. The precise location of some of the older subsurface infrastructure is not known. This infrastructure would be a significant obstacle to implementing any type of active remediation under or around the building.

2.0 Current Conditions

This section describes the current conditions at the Building 100 Area as they relate to the screening of remediation alternatives. The relevant items are hydrogeologic conditions, COPCs, cleanup goals, nature and extent of contamination, and affected environmental pathways.

2.1 Site Hydrogeology

The STAR Center is located in Pinellas County, which sits on the western flank of the Florida Platform within the Atlantic Coastal Plain Geologic Province. The Florida Platform is composed predominantly of thick sequences of carbonate rocks deposited in a shallow marine environment, and capped by a thin, siliciclastic, sediment-rich sequence (Scott et al. 1991). The following formations, from shallowest to deepest, are present beneath the STAR Center: surficial deposits, Hawthorn Formation (Hawthorn), Tampa Limestone, Suwannee Limestone, Ocala Limestone, and Avon Park Formation (Figure 9). The topography at the STAR Center is generally flat.

2.1.1 Surficial Aquifer

The uppermost sediments compose the surficial aquifer and consist of silty-to-shelly, fine-grained sands. Currently, no municipal water supplies are derived from the surficial aquifer because of the poor quality and limited availability of the ground water (DOE 1991). The principal use of surficial aquifer ground water is for irrigation.

The surficial aquifer at the Building 100 Area ranges in thickness from approximately 35 feet (ft) to 40 ft, based on lithologic logs from drilling activities around the perimeter of the building in May 1995. The surficial sediments and underlying Hawthorn are shown on the cross section in Figure 10. A series of grain-size analyses was run on sediments collected from two boreholes advanced just outside the northwest corner of Building 100 during the 1995 drilling activities (Table 1). These analyses show that the surficial aquifer matrix is mostly sand, but that layers of shelly sand and silty sand are present, indicating significant subsurface heterogeneity and the potential presence of preferential pathways.

Table 1. Building 100 Area Surficial Sediments Description

Well	Sample interval (ft bls)[a]	Description
PIN12–0520	10–12	Shelly Sand
PIN12–0520	15–17	Shelly Sand
PIN12–0520	20–22	Silty Sand
PIN12–0520	25–27	Silty Sand
PIN12–0520	30–32	Shelly Sand
PIN12–0520	35–37	Sand
PIN12–0520	40–42	Sand
PIN12–0520	45–47	Clayey Sand
PIN12–0520	47–49	Clayey Sand
PIN12–0522	40–42	Clayey Sand
PIN12–0522	42–44	Clayey Sand
PIN12–0522	44–46	Sandy Clay

[a]bls = below land surface

In May 1995, specific-capacity tests were performed on monitoring wells PIN12–0520, –0521, −0522, and –0523, which are located outside the northwest corner of Building 100. The purpose of these tests was to estimate the horizontal hydraulic conductivity of the surficial aquifer in the immediate vicinity of the tested wells, based on the Theis equation for nonequilibrium, horizontal flow (Butler 1957; Walton 1962). Estimated hydraulic conductivity values are summarized in Table 2. These hydraulic conductivity values for the surficial aquifer are in agreement with previous estimates, based on slug tests around Building 100, of 0.17 to 1.3 ft/day (DOE 1991). These relatively low hydraulic conductivity values indicate that ground water velocity should be relatively low. Ground water velocity also is dependent upon the hydraulic gradient, discussed in the second paragraph following.

Table 2. Estimated Hydraulic Conductivity at the Building 100 Area

Well	Screened Interval (ft bls)	Estimated Horizontal Hydraulic Conductivity (ft/day)
PIN12–0520	36–46	0.47
PIN12–0521	19.5–29.5	1.35
PIN12–0522	32–42	0.59
PIN12–0523	18–28	2.06

In the Building 100 Area, depth to water ranges from about 1 to 5 ft bls, depending on the season and recent rainfall. Current ground water elevations and contours for the shallow and deep surficial aquifers at the STAR Center are shown on Figures 11 and 12, respectively. The surficial aquifer is interpreted as having shallow and deep components based on the presence of a dark brown, organic “hardpan” layer that is often present at about 20 ft bls, but is discontinuous throughout the subsurface beneath the STAR Center. Water levels in well pairs set in the shallow and deeper portions of the surficial aquifer support the two-component interpretation. Flow in both components of the surficial aquifer is influenced by ground water withdrawals from two recovery wells located outside the northwest corner of the building. Shallow ground water

beneath Building 100 flows to the southeast under natural conditions, but flows back towards the northwest in areas within the capture zones of the recovery wells.

In the shallow surficial aquifer, the hydraulic gradient beyond the influence of pumping is typically about 0.005 ft/ft or less based on quarterly and semiannual water level measurements. Darcy's Law, along with approximations of 1 ft/day for hydraulic conductivity and 0.3 for effective porosity, indicates that ground water in the shallow surficial aquifer travels an estimated 6 ft/year. Ground water in the deeper surficial aquifer is estimated to travel at about one-half that velocity.

2.1.2 Hawthorn Formation

Underlying the surficial aquifer is the Hawthorn Formation, which is composed of sand, clay, limestone, and dolomite, and forms a widespread dividing layer between the surficial aquifer and the Tampa Limestone (Figure 9). The Hawthorn ranges from 55 to 78 ft in thickness in the area of the STAR Center (DOE 1991). Depth to the top of the Hawthorn in the Building 100 Area generally ranges from about 35 to 40 ft bls, but has been logged as deep as 46 ft bls at the location of well PIN12–0520. The upper portion of the Hawthorn consists of sandy clay with hard, weathered limestone, or other carbonate lenses.

Aquifer tests to estimate the hydraulic properties of this formation were conducted as part of the sitewide RFI. Results indicated that the Hawthorn has an average vertical hydraulic conductivity of 0.0011 ft/day. The estimated vertical travel time for ground water movement through the formation is a few hundred years (DOE 1991). This estimate considered only conservative movement of ground water, and does not account for retardation of contaminants via sorption to the aquifer matrix and biodegradation reactions, both processes that would further restrict contaminant movement. Thus, in the vicinity of the STAR Center, the Hawthorn is considered an aquitard (i.e., a semiconfining geologic unit that restricts vertical ground water flow). Results from these aquifer tests indicate that it is very unlikely that contamination in the surficial aquifer will travel through the Hawthorn and affect the underlying Floridan aquifer (DOE 1991).

2.1.3 Floridan Aquifer

Underlying the Hawthorn is the Tampa Limestone, which is the uppermost unit of the Floridan aquifer (Figure 9). The Tampa Limestone consists of clayey, weathered limestone with varying amounts of quartz sand, phosphate, and fossils. Beneath the Tampa Limestone is the Suwanee Limestone, which consists of hard, fossiliferous limestone that may contain interbeds of quartz sand and chert. The underlying Ocala Limestone is considered a semiconfining unit and is composed of granular, porous limestone. The Avon Park Formation, the major water-bearing zone of the upper Floridan aquifer, is characterized by microcrystalline dolomite and soft porous limestone. The Floridan aquifer is the main source of drinking water in the area.

2.2 Contaminants of Potential Concern

RFI data collection activities at the Old Drum Storage Site addressed the potential for soil contamination resulting from spills that may have occurred at the site in the past. Soil samples were collected in 1990 and 1991 and analyzed for VOCs and metals, and a number of compounds were detected. An EPA methodology based on magnitude of concentration and

toxicological properties indicated that soil contaminant concentrations did not exceed EPA soil screening levels, and therefore no COPCs were identified for soil. During the RFI, soil sampling directly beneath Building 100 was not possible due to the difficulty of this operation, the lack of information on utility locations, and the interruption of operational activities that would have resulted (DOE 1991).

In 1995, during DOE cleanup of the facility prior to transfer to Pinellas County, three phases of soil sampling, in conjunction with the installation of monitoring wells, were conducted beneath vacated areas of Building 100. Soil samples were collected only from the unsaturated zone within approximately 3 or 4 ft beneath the floor slab; no soil samples were collected below the water table. Analytical results demonstrated that VOCs and metals in these soil samples were below EPA soil screening levels, except for arsenic at five locations along the northern edge of Building 100.

The RFI Report (DOE 1991) determined that the only medium of concern at the Building 100 Area was ground water, and that soil remediation was not required. That determination received regulatory approval through subsequent state-approved reports (DOE 1994, 1996a, and 1998). On the basis of that determination, the scope of this document is confined to evaluation of ground water remediation alternatives.

Ground water COPCs are discussed in Section 2.2.1, and initial cleanup goals are presented in Section 2.2.2.

2.2.1 Contaminants of Potential Concern for Ground Water

The RFI Report (DOE 1991) identified COPCs for ground water associated with the Old Drum Storage Site and Building 100 Industrial Drain Leaks. This COPCs list is the same list that was included in the CMS Report (DOE 1994), the CMIP (DOE 1996a), and the CMIP Addendum (DOE 1998).

This COPCs list was evaluated in detail in the *Historical Review and Evaluation of Contaminants of Potential Concern* (DOE 2003). This evaluation resulted in five compounds being retained as COPCs (Table 3):

- trichloroethene (TCE),
- 1,1-dichloroethene (1,1-DCE),
- *cis*-1,2-dichloroethene (cDCE),
- *trans*-1,2-dichloroethene (tDCE), and
- vinyl chloride (VC).

Additionally, arsenic was added to the COPCs list in 2005, based on data collected since 2003 (DOE 2005; Table 3).

Table 3. Ground Water COPCs and Cleanup Goals for the Building 100 Area

COC	Cleanup Goals (FDEP Drinking Water Standards) (µg/L)[a]
Trichloroethene (TCE)	3
cis-1,2-Dichloroethene (cDCE)	70
trans-1,2-Dichloroethene (tDCE)	100
1,1-Dichloroethene (1,1-DCE)	7
Vinyl chloride (VC)	1
Arsenic	10

[a]µg/L = micrograms per liter

The presence of 1,1-DCE, cDCE, and VC likely is due to biodegradation of TCE via a reductive dechlorination pathway. TCE is commonly referred to as the parent compound, and the biodegradation intermediates are called daughter products. As shown in Figure 13, TCE biodegrades to cDCE, tDCE, or 1,1-DCE, and these DCE isomers then biodegrade to VC and then to ethene or ethane. tDCE was documented as being used as a solvent during DOE activities, so it may have been released directly to the subsurface, but it also may be a daughter product of TCE biodegradation. Biodegradation is discussed in more detail in Section 2.3.4.

2.2.2 Initial Cleanup Goals

Per EPA and FDEP direction, the cleanup goals identified for ground water in the original CMS were FDEP drinking water MCLs. These MCLs are listed for the individual COPCs in Table 3. A reevaluation of cleanup goals is conducted in this addendum based on updated knowledge of the site and changes in the regulatory framework (see Section 5.1 for further discussion).

2.3 Nature and Extent of Contamination at the Building 100 Area

This section presents the nature and extent of contamination at the Building 100 Area, including an evaluation of the potential presence of contaminant sources and an evaluation of plume stability. As mentioned in Section 2.2, soils are not a medium of concern, so only ground water contamination is addressed in this section. The information presented in this section is used to refine the existing conceptual model for the site. The revised conceptual site model is presented in Section 2.4.

2.3.1 Nature and Extent of Ground Water Contamination

To aid the reader in evaluating the data discussed in this section, Table 4 lists the screened interval of each well at the Building 100 Area.

2.3.1.1 Plume History

During the RFI, ground water samples were collected from 12 wells installed around the perimeter of the building (DOE 1991). These wells were screened from 3 to 13 ft bls, and samples from these wells indicated that contaminant concentrations were relatively low or below detection limit.

Subsequent to the RFI, a number of additional ground water investigations were conducted by installing additional temporary and permanent wells around the perimeter of the building, through the floor of the building, and in the areas near the property boundary to the south and east of the building (DOE 1994, 1996a, 1996b, 1996c, 1998). A summary of Building 100 Area historical data is shown in Table 5. These investigations resulted in revisions to the previous conceptual model of ground water contamination at the Building 100 Area by determining the following:

- Contaminant concentrations were considerably higher than previously thought;
- Contamination was present in middle and deep areas of the surficial aquifer;
- High contaminant concentrations were present under the building; and
- Low contaminant concentrations were present to the south and east of Building 100 to near the property boundary.

Table 5. Summary of Historical Ground Water Data for the Building 100 Area

COC	Maximum Concentration (µg/L)	Average of Detected Values (µg/L)	Number of Detections	Total Number of Analyses	Percentage of Detections
Trichloroethene	80,000	5,317	564	2,457	23
cis-1,2-Dichloroethene	110,000	3,167	1,268	2,187	58
trans-1,2-Dichloroethene	19,000	449	652	2,157	30
1,1-Dichloroethene	3,700	189	398	2,182	18
Vinyl chloride	41,000	630	1,258	2,489	51

These investigations defined the depth and lateral extent of the contaminant plume in areas adjacent to the building, but the area under the building received minimal characterization due to the large size of the building, areas of limited access, and equipment limitations inside the building. Subsequent monitoring has confirmed the plume extent in areas outside the building footprint, but characterization under the building remains very limited.

2.3.1.2 Lateral Extent of Contamination

The current status of ground water contamination in the Building 100 Area is based on data collected during the March 2006 annual sampling event, wherein all 61 active monitoring wells and the two recovery wells at the Building 100 Area were sampled. Table 6 shows a summary of the most recent data for each COPC at the Building 100 Area, and Table 7 shows the March 2006 data for each COPC at each well.

Monitoring points PIN12−S54D; −S55B, C, and D; −S56B, C, and D; −S57B, C, and D; −S59B, C, and D; and –S60B, C, and D provided all the contaminant data from the central part of the building (Figure 7), but were removed from the fiscal year 2006 sampling plan because of significant deterioration, as described in Section 2.3.5. Many of these wells showed high levels of contamination, so an evaluation of ground water contamination would be incomplete without considering these data. Therefore, the most recent data from these monitoring points, from April or October 2005, have been used in the evaluation of the current status of ground water contamination.

Table 6. Summary of March 2006 Water Quality Data Collected at the Building 100 Area

COC	Maximum Concentration (µg/L)	Average of Detected Values (µg/L)	Number of Detections (out of 79 analyses)	Number of Detections > Cleanup Goal	Cleanup Goal (µg/L)
Trichloroethene	16,600	1,864	16	11	3
cis-1,2-Dichloroethene	53,200	3,189	41	15	70
trans-1,2-Dichloroethene	9,150	383	28	3	100
1,1-Dichloroethene	465	75	18	8	7
Vinyl chloride	16,000	1,079	40	36	1

The total COPCs plume map shown in Figure 7 demonstrates that a plume of dissolved VOCs extends from the vicinity of the Old Drum Storage Site at the northwest corner of Building 100, beneath a good portion of the building, and into areas south and east of the building to near the property boundary. This VOCs plume includes all detected COPCs with concentrations greater than the MCL.

TCE, cDCE, and VC are the COPCs found at the highest concentrations and with the widest distribution, so they are discussed in detail here. 1,1-DCE and tDCE generally are present at much lower concentrations and are not as widely distributed, and so are not discussed in detail. TCE above the 3 micrograms per liter (µg/L) cleanup goal (Figure 14) was found

- As a plume extending from the Old Drum Storage Site to near the center of the western half of the building,
- In well S57 near the center of the building, and
- In well 0524 near the southeast corner of the building.

The likely source for the TCE under the northwestern part of the building is activities associated with the old drum storage pad and possibly a drain leak in the vicinity of well S35B. The source of the TCE in the S57 wells and well 0524 is likely drain leaks.

cDCE above the 70 µg/L MCL was found in the same areas as the TCE plume and also extended to areas hydraulically downgradient from the TCE plume (Figure 15). tDCE and 1,1-DCE were found in the highest concentrations in the same areas as cDCE, near the northwest corner of the building and in the S57 wells. The likely source of cDCE, tDCE, and 1,1-DCE is biodegradation of TCE.

A large plume of VC above the 1 µg/L cleanup goal was found extending from the Old Drum Storage Site, under much of Building 100, and to near the eastern and southern property boundaries (Figure 16). The likely source of VC is biodegradation of cDCE, tDCE, or 1,1-DCE. Contaminant biodegradation at the Building 100 Area is discussed in more detail in Section 2.3.4. VC defines the leading edge of the contaminant plume, and is present at very low concentrations (<10 µg/L) in monitoring wells located near the property boundary (Figure 16). These wells are located 40- to 50-ft hydraulically upgradient from the property boundary. Based on the distance of these wells from the property boundary, very low ground water velocity, very low VC concentrations, and attenuation via natural processes such as biodegradation and

dilution, it appears likely that VC concentrations above the 1 µg/L MCL do not extend off the property.

From the observed distribution of contamination, it would appear that the Old Drum Storage Site is probably a source of some of the contamination. Additionally, high concentrations of contamination are found in isolated areas under Building 100, indicating that documented drain leaks (DOE 1987a, 1987b) may be the source of some of the contamination. Therefore, based on the current extent of characterization, it would appear that the Building 100 Area has multiple contaminant sources unevenly distributed over a large area under Building 100.

2.3.1.3 Depth of Contamination

In general, most contamination at the Building 100 Area is located at medium to deep depths in the surficial aquifer. Wells screened at shallow depths (down to approximately 15 ft bls) have relatively lower contaminant concentrations, while wells screened to depths of 25, 30, and 40 ft bls show relatively higher contaminant concentrations. Exceptions to this generality are wells such as PIN12−S30B, −S35B, and –S55B located in the northwestern part of the building and screened at 5−15, 5−15, and 10−20 ft bls, respectively. These three wells likely are relatively near a contaminant source area, and the shallow contaminant detections reflect the presence of residual NAPL in shallow areas of the surficial aquifer.

Figures 17 and 18 are cross sections showing the depth of contamination from the northwest corner of the building to the southern property boundary, along a line generally parallel to ground water flow direction. Although some shallow wells under the building show high levels of contamination, the wells hydraulically downgradient from the building (to the south and east) contain very low COPCs concentrations, and, in fact, most are non-detect. VC is the only COPC measured above MCLs in wells located downgradient from the building, with the exception of TCE, cDCE, and 1,1-DCE in well PIN12−0524. VC is detected at very low concentrations in the wells nearest the property boundary: 1.1 µg/L in PIN12−S72C, 9.3 µg/L in PIN12−S73C, and 7.1 µg/L in PIN21−0512.

The surficial deposits/Hawthorn contact occurs between 35 and 46 ft bls in the Building 100 Area (Section 2.1.2). The Hawthorn is approximately 70 ft thick and provides an effective aquitard between the contaminated water in the surficial aquifer and the water in the Floridan aquifer, as indicated by the estimated 630 years required for ground water to travel from the surficial aquifer to the Floridan aquifer, as discussed in Section 2.1.2. Data from the two wells screened in the Floridan aquifer (PIN12−0527 and –0528; Figure 7; Table 4) have shown that the Floridan aquifer is not affected by site-related contamination in the surficial aquifer.

2.3.1.4 Plume Stability Beneath the Building

This section contains a summary of stability of the contaminant plume beneath Building 100. A detailed evaluation of plume stability, including COPC concentration trends over time, is included in Appendix A, Figures A−1 through A−4.

The monitoring wells beneath Building 100 that contain the highest COPC concentrations generally show decreasing COPC concentration trends over the last 3−5 years, indicating that depletion of the contaminant source probably is occurring in most areas. At some locations, COPCs daughter products cDCE or VC show increasing trends that likely are due to naturally

occurring biodegradation. COPC source depletion and biodegradation demonstrate that the plume currently is stable, and indicate that the plume will shrink in the future.

2.3.1.5 Plume Stability Downgradient From the Building

This section contains a summary of stability of the contaminant plume hydraulically downgradient from Building 100, to the south and east of the building. A detailed evaluation of plume stability, including COPC concentration trends over time, is included in Appendix A, Figures A−5 through A−20.

The COPC plume downgradient from the building is stable, as evidenced by low contaminant concentrations, stable or decreasing concentration trends over time, and clear evidence of biodegradation. VC is generally the only COPC present at concentrations greater than the 1 µg/L MCL. However, it is present generally at very low concentrations, less than 10 µg/L in many wells. VC concentrations greater than the MCL likely do not extend off the property, based on very low concentrations in wells nearest the property boundaries.

2.3.2 Non-Aqueous Phase Liquids

TCE and cDCE were measured in 2005 and 2006 at concentrations that potentially indicate that these compounds could be present as NAPLs (Table 8). EPA has suggested that when the dissolved concentration of a compound exceeds 1 percent of its aqueous solubility, it may be assumed that this compound could be present as a NAPL in a location hydraulically upgradient from the well (EPA 1992). The aqueous solubilities of TCE and cDCE are 1,100,000 µg/L and 5,000,000 µg/L; 1 percent of the aqueous solubilities are 11,000 µg/L and 50,000 µg/L, respectively.

Table 8. Measured Concentrations of TCE and cDCE in 2005 and 2006 Indicating Potential NAPL Presence

Compound	Well	Date Sampled	Measured Concentration (µg/L)	Percent of Aqueous Solubility
TCE	PIN12–S35B	4/8/2005	23,800	2.2
	PIN12–S35B	10/7/2005	11,600	1.1
	PIN12–S35B	3/9/2006	16,600	1.5
*c*DCE	PIN12–S35B	4/8/2005	67,600	1.4
	PIN12–S35B	3/9/2006	53,200	1.1

The historical maximums for TCE and cDCE concentrations at the Building 100 Area are 80,000 µg/L and 110,000 µg/L (Table 5), equating to 7.3 percent and 2.2 percent of the compounds' aqueous solubilities, respectively.

TCE use has been documented at the former Pinellas Plant (DOE 1987a, 1987b) and TCE NAPL has been identified at the STAR Center's Northeast Site. The use of cDCE at the former Pinellas Plant has not been documented, although tDCE use has been confirmed (CH2MHill 1987). As mentioned in Section 2.2.1, cDCE is a common intermediate formed during TCE degradation, and it is possible that cDCE concentrations above 1 percent of the solubility could result solely

from TCE degradation. However, cDCE NAPL has also been identified at the Northeast Site. This fact, along with the observation of cDCE at concentrations greater than 1 percent of solubility, indicates the potential for cDCE presence as a NAPL at the Building 100 Area. All elevated cDCE concentrations have been observed concurrently and at the same locations as elevated TCE concentrations, so for the purposes of this document, the assumption has been made that all potential cDCE NAPL is co-located with TCE NAPL.

Historically, TCE concentrations greater than one percent of the solubility have been measured in six wells (Figure 14; Table 9). These wells are screened at shallow, medium, and deep depths, indicating that non-aqueous phase TCE may be dispersed throughout the surficial aquifer. TCE is denser than water, so any TCE released to the subsurface would tend to sink through the ground water.

Table 9. List of Wells That Have Historically Contained TCE Concentrations Greater Than One Percent of the Aqueous Solubility

Well	Screened Interval (ft bls)	Maximum TCE Concentration (µg/L)	Percent of Aqueous Solubility	Date
PIN12–RW01	19−29	16,000	1.5	3/3/1999
PIN12–S30B	5−15	23,000	2.1	7/12/2002
PIN12–S33C	11−21	37,000	3.4	1/15/1996
PIN12–S35B	5−15	80,000	7.3	1/13/1998
PIN12–S54D	36−41	15,000	1.4	7/12/2002
PIN12–S57C	20.5−30.3	68,000	6.2	1/11/1999

Large pools of non-aqueous phase TCE probably are not present at the Building 100 Area, based on the current extent of characterization and the comparison with contaminant concentrations at the STAR Center's Northeast Site where NAPL has been observed in wells. It is probable that sporadic drain leaks resulted in relatively small volumes of waste entering the subsurface, where it would move downward through the unsaturated zone until it dispersed into small globules remaining in the soil matrix.

The Old Drum Storage Pad was removed in 1986, and the drains under Building 100 were grouted and abandoned by 1994, so at least 12 years have passed since any NAPL was released into the subsurface. Therefore, any NAPL in the subsurface is no longer moving, having reached a stationary position within the aquifer matrix.

2.3.3 Geochemical Conditions

Geochemical parameters measured within the last 2 years at the Building 100 Area are summarized in Table 10. As indicated by the average values, most dissolved oxygen and oxidation-reduction potential measurements were low, indicating that reducing conditions are present throughout most of the surficial aquifer. Ground water temperatures are relatively warm because of the subtropical climate, and pH is generally near neutral. These data indicate that conditions are conducive to natural biodegradation of the contaminants.

Table 10. Summary of Geochemical Data From 2005 and 2006 for All Wells at the Building 100 Area

Parameter	Minimum Value	Maximum Value	Average Value
Dissolved Oxygen (mg/L)	0.19	7.62	0.64
Oxidation Reduction Potential (mV)	−463	198	−53
pH (s.u.)	5.75	8.89	6.71
Specific Conductance (µmhos/cm)	180	2,421	1,048
Temperature (°C)	20.7	31.6	24.8
Turbidity (NTU)	0.3	1,000	83

2.3.4 Biodegradation Processes

A considerable amount of data related to biodegradation processes has been collected at the Building 100 Area since 2002 (Table 11). Research over the last few years has demonstrated that the *Dehalococcoides ethenogenes* (DHC) microorganism is the only organism capable of causing complete dechlorination of TCE, DCE, and VC to ethene, ethane, or other innocuous compounds (Figure 13). The STAR Center is one of the type sites for this organism, and the Pinellas culture of DHC was named following the collection and characterization of this organism at the STAR Center's Northeast Site in 1997.

DHC has been measured at concentrations ranging from non-detect to a high abundance, although most concentrations were moderate (Table 11). All wells that have shown non-detect DHC concentrations have shown detectable concentrations during previous or subsequent sampling events. Most non-detects occurred during the dry season (winter and spring). Clearly, DHC is present during at least part of the year in all wells.

The dissolved gasses ethane, ethene, hydrogen, methane, and carbon dioxide have been analyzed numerous times in Building 100 Area wells (Table 11). Ethane and ethene are direct metabolites from TCE/DCE/VC biodegradation and have no source other than contaminant biodegradation. Methane and carbon dioxide also are potential contaminant metabolites, but may have other sources such as biodegradation of natural organic matter. Ethane and ethene are generally found at non-detect to low concentrations in wells containing low contaminant concentrations (e.g., well S73C), but are found at relatively high concentrations in wells with high contaminant concentrations (e.g., well S35B). The lack of ethane and ethene detections in some wells, such as 0526, does not necessarily indicate a lack of biodegradation, but may instead indicate that processes are slow (i.e., DHC concentrations are low) or that ethane and ethene could be present below the detection limit.

Hydrogen is not a metabolite, but is a good indicator of the redox state of the ground water. Hydrogen concentrations greater than 1 nanomole/L indicate that conditions are favorable for reductive dechlorination to occur (EPA 2000). Most measured hydrogen concentrations are near or greater than 1 nanomole/L (Table 11).

Another obvious indicator of biodegradation is the presence of the TCE daughter products DCE and VC. As discussed previously, tDCE has been used at the site and therefore may have been

released to the subsurface, but it is highly likely that cDCE, 1,1-DCE, and VC are the result of TCE biodegradation (Figure 13).

In summary, there is substantial evidence that biodegradation is a significant natural attenuation process occurring at the Building 100 Area. Also, the presence of ethane and ethene demonstrate that biodegradation is going to completion.

2.3.5 Data Gaps

Considering the size of Building 100 (approximately 11 acres), the amount of characterization that has been conducted under the building is minimal, particularly in light of the potential presence of NAPLs. Currently there are only nine sampling locations (11 wells) under the building, and most of these are grouped at the northwest side of the building (Figure 7).

Sixteen monitoring points under Building 100 were removed from the list of active monitoring wells for fiscal year 2006 (DOE 2005) and, therefore, were not sampled in March 2006. These monitoring points (PIN12−S54D; −S55B, C, and D; −S56B, C, and D; −S57B, C, and D; −S59B, C, and D; and –S60B, C, and D) were installed in January 1997 using direct-push technology and were completed with no annular space, and thus, no filter pack or grout seal. They are constructed of welded sections of 7/8-inch-diameter carbon steel pipe with a 5- to 10-ft section of slotted pipe at the bottom. Due to the limitations of working inside the building, these well materials and the direct-push technology installation method were the best available options to allow for collection of ground water samples from beneath the building, even though the well points do not strictly meet the requirements of monitoring wells as described by EPA. These points were never intended for long-term use and have been steadily deteriorating over the past few years. The small diameter of the well points prohibits the installation of bladder pumps, and therefore, they are purged with a peristaltic pump and sampled with dedicated Teflon tubing. The last time these wells were sampled, in April 2005, most of the well points either purged dry or yielded so little water that, at best, an air/water mixture was “slurped” out during purging, and a consistent flow rate could not be achieved. Due to the physical limitations of the building and the fact that all areas of the building are occupied by tenants, it will not be possible to install any additional monitoring wells through the floor of the building.

The locations of the drain leaks under the building are unknown, and because of the limited number of wells under the building, there is potential for unidentified NAPL or high contaminant concentrations to exist. An exhaustive attempt was made recently to locate documents that would identify the location of the drain leaks, but apparently these documents no longer exist.

2.3.6 Contaminant Impact on Resources

The most significant natural resource in the vicinity of Building 100 is the ground water. The Floridan aquifer, which is the primary drinking water aquifer in the region, is located at least 110 ft below land surface and separated from the surficial aquifer by the 70-ft-thick clay layer of the Hawthorn Formation. There is no evidence of adverse impact to the water of the Floridan aquifer.

The surficial aquifer, comprising approximately the upper 40 ft of the subsurface, contains known COPCs at concentrations indicating the potential presence of NAPL. However, even the uncontaminated water of this aquifer has limited value because it does not meet secondary

drinking water standards for iron and aluminum (DOE 2003). Therefore, the cost to treat the water to meet drinking water standards is likely prohibitive. Furthermore, municipal water is available to all households in the area, providing better quality water at less cost. The only current use of water from the surficial aquifer on site is irrigation, which has not been affected by contamination.

Based on these observations, the site-related contaminants have no significant impact on resources.

2.4 Conceptual Site Model

The Building 100 Area consists mainly of an 11-acre building surrounded by 46 acres of buildings, paved parking lots, and roadways. The building contains 15 tenant companies employing over 1,100 people. The current infrastructure and land use preclude intrusive investigations to characterize or delineate the contaminants. The building and surrounding ground cover greatly restrict aquifer recharge from precipitation, but ground water still flows southeast beneath the building from the West Pond, a surficial aquifer recharge area located approximately 800 ft northwest of the building. The South Pond, located to the south of Building 100, also receives runoff and is a recharge area. Water from the ponds on the site is used for irrigation.

The subsurface consists of 35−40 ft of fine, silty sand underlain by the clay aquitard of the Hawthorn Formation. Ground water velocity in the shallow surficial aquifer is estimated at approximately 6 ft/year, and likely is slower in the deep surficial aquifer. Depth to ground water ranges from about 1 to 5 ft bls, depending on the season and recent rainfall. Field observations and ground water modeling have demonstrated the existence of preferential ground water flow pathways in the surficial aquifer. These pathways would be a significant complication to the implementation of any active remediation technology that involved injecting material into the subsurface, in that it may be difficult or impossible to contact all areas of the subsurface. Likewise, these pathways could complicate or preclude any activity involving extraction of small discrete areas of contamination, such as NAPL.

Contaminants, as either pure-phase solvents (NAPL) or dissolved in wastewater, were released from multiple point sources over a 30- to 40-year time period, including releases from the Old Drum Storage Site and drain/piping leaks under the building (Figure 19). The mass of solvents released into the subsurface and the locations of the releases via drain leaks are unknown. The drum storage pad has been removed and piping has been plugged, but residual product may remain in the aquifer matrix. Because at least 12 years have passed since any NAPL releases have occurred, the potential NAPL is stationary within the aquifer matrix. Contaminant concentrations in ground water suggest that small amounts of TCE or cDCE NAPL may be present.

Initially, it was believed that the contaminant plume was confined to a small area near the northwest corner of Building 100. However, additional characterization has shown that the dissolved-phase contaminant plume extends from the northwest corner of the building approximately 1,400 ft to the southeast, near the southeastern property boundary of the STAR Center (Figure 7). Elevated contaminant concentrations are present near the northwest corner of the building and in areas under the building. Characterization under the building is poor, with no

potential for additional characterization, so the exact extent and magnitude of contamination there is unknown. Concentrations downgradient to the south and east of the building are generally very low. There is no evidence that contaminant concentrations above MCLs are present off the property. Contamination is present at shallow depths at a few locations under the northwest part of the building, but in general, contamination is found only at medium and deep intervals in the surficial aquifer. The 70-ft-thick aquitard of the Hawthorn prevents contamination in the surficial aquifer from reaching the Floridan aquifer.

The contaminant plume appears to be generally stable both under the building and hydraulically downgradient to the south and east. Contaminant concentrations in most wells are either stable or decreasing. A few wells show increasing contaminant concentrations, but most of these likely are transient effects due to biodegradation producing daughter products such as DCE and VC. Natural, complete biodegradation of the chlorinated solvents has been clearly documented, demonstrating dechlorination of TCE, DCE, and VC to ethene. This process appears to be the dominant force stabilizing the dissolved-phase plume.

The generally very stable concentration trends observed in wells downgradient from the building indicate that a stable dynamic equilibrium exists in the plume. A constant mass of contaminants is present in the ground water emerging from under the building, and natural attenuation processes such as biodegradation and dilution are acting on this mass to produce the stable concentrations observed in the wells near the property boundary. This dynamic equilibrium likely will continue until the contaminant source (probably TCE or cDCE NAPL and the associated high sorbed concentrations) is depleted, and then the plume likely will start to shrink.

There are no known complete human or ecological exposure pathways. Modeling (discussed in Section 2.5) has shown that contaminant vapors are not intruding into the building. Contamination is located only at deep intervals in the surficial aquifer in areas not under the building, so contaminated ground water is not entering the South Pond.

2.5 Potential Exposure Pathways

Based on the current conceptual site model, contamination associated with the Building 100 Area is confined to the surficial aquifer. Downward movement of contamination into the Floridan aquifer is prevented by the presence of the thick aquitard of the Hawthorn. There are no direct surface exposure pathways. Contaminants in the subsurface can migrate as dissolved phases in ground water or volatilize and migrate through the vapor phase.

An evaluation of potential impacts of subsurface vapor intrusion to indoor air in Building 100 was completed as part of the Environmental Indicators program required by the Government Performance Results Act of 1993 (GeoSyntec 2003). Site-specific data were used in a model to estimate indoor air concentrations using appropriate (and conservative) assumptions and methodologies. Estimated indoor air concentrations were more than an order of magnitude below the target levels for TCE, cDCE, and VC. It was concluded that the indoor air pathway is not of concern for Building 100.

Data presented in previous sections in this document have indicated that contaminants in the surficial aquifer have migrated away from the presumed source areas with ground water flow. However, the contaminant plumes are confined to the site boundaries and are stable. Surface

water bodies are located at the downgradient edge of the plume (e.g., the South Pond) and are connected with the alluvial aquifer. However, the ponds are shallow (approximately 10 ft or so; Figure 17), and contamination at the downgradient portion of the plumes is intermediate to deep (20 to 40 ft bls). Therefore, contaminated ground water is not being discharged to the surface via this pathway. Even if minor amounts of contaminants were to discharge to the ponds, they would quickly degrade and/or volatilize under surface conditions.

Based on the current conceptual site model, the only complete exposure pathway to site-related contamination would be through installation of wells and extraction of ground water in the surficial aquifer within the site boundary.

2.6 Summary of Current Conditions

Ground water contamination in the Building 100 Area is limited to the surficial aquifer. This aquifer, characterized by low yield of poor quality water useful only for irrigation, comprises the upper 35 to 40 feet of sediments. It has a heterogeneous matrix with potential preferential pathways, very low ground water flow velocity in its shallow interval, and even lower ground water flow velocity in its deep interval. The tight clay of the 70-foot-thick Hawthorn Formation underlies the surficial aquifer and prevents downward migration of ground water contaminants. The Hawthorn has an extremely low vertical hydraulic conductivity, with an estimated travel time of several hundred years to penetrate.

Ground water contaminants are limited to arsenic, TCE, and TCE degradation products resulting from multiple long-term point sources beneath Building 100. Investigations subsequent to the 1994 CMS Report identified contamination in the intermediate and deep intervals of the surficial aquifer, high contaminant concentrations beneath Building 100 that indicate the presence of NAPL, and low contaminant concentrations southeast of Building 100. The consistently low concentrations observed in the monitoring wells downgradient from Building 100 demonstrate that the contaminant plume is stable, likely due to the extremely low ground water flow velocity and naturally occurring, robust biodegradation processes documented on site. These processes degrade TCE to DCE to VC to ethene, ethane, and other innocuous compounds.

The amount of characterization data currently available is inadequate to support proven remediation technologies, and additional characterization is not possible without disrupting the existing tenants. However, there has been no significant impact on resources, and there are no known complete human or ecological exposure pathways.

3.0 Remediation Objectives

Remediation objectives in this CMS addendum were developed according to EPA's *Handbook of Groundwater Protection and Cleanup Policies for RCRA Corrective Action* ("Handbook;" EPA 2004). The development of these objectives also takes into account recent changes in the regulatory framework governing site cleanups, particularly the more accepted and widespread use of ICs.

EPA's Handbook recommends that ground water cleanups be implemented in terms of short-term protection goals, intermediate performance goals, and final cleanup goals. Achievement of

short-term protection goals is determined by two environmental indicators: “Current Human Exposures Under Control” and “Migration of Contaminated Ground Water Under Control” (EPA 2004). At the Building 100 Area, these environmental indicators and, therefore, short-term protection goals have been met (EPA 2003a). The focus of this addendum is, therefore, on meeting longer-term remedial objectives.

3.1 General Remediation Objectives

The general objectives for remediation at the Building 100 Area are as follows:

- Protect human health and the environment.
- Control the source of releases to reduce or eliminate, to the extent practicable, further releases that may pose a threat to human health and the environment.
- Comply with applicable standards for management of wastes.

The focused objectives for remediation at the Building 100 Area are as follows:

- Comply with contaminated site cleanup criteria (Chapter 62-780 F.A.C.).
- Conduct remediation in a manner such that activities do not impact Building 100 occupants.
- Conduct remediation in a manner such that activities cause minimal impact to public perception.

4.0 Identification and Evaluation of Active Remediation Alternatives

This section provides a list and description of active remediation alternatives (Section 4.1), determines the criteria against which the alternatives are evaluated (Section 4.2), and then presents the evaluation of both the current remediation system (Section 4.3) and the list of alternatives (Section 4.4).

4.1 Identification of Active Remediation Alternatives

A complete list of active remediation technologies was assembled following review of several sources of information. The scientific literature was reviewed to identify technologies and obtain peer-reviewed information and data about the performance of the technologies. Online resources also provided a significant amount of information. In particular, the Federal Remediation Technologies Roundtable (FRTR) was a valuable source of remediation technology information (FRTR 2006). The FRTR member agencies are the U.S. Department of Defense, EPA, DOE, the U.S. Department of the Interior, the U.S. Department of Commerce, the U.S. Department of Agriculture, and the National Aeronautics and Space Administration.

The FRTR provided a treatment technology matrix that identified most treatment technologies. This matrix was adapted to produce Table 12, which lists and provides a brief description of the treatment technologies. A few additional treatment technologies were identified through other sources, and these were added to Table 12. Other sources of technology information included EPA’s CLU-IN and REACH-IT websites, Interstate Technology and Regulatory Council,

Remediation Technologies Development Forum, Ground Water Remediation Technologies Analysis Center, Environmental Security Technology Certification Program, and Strategic Environmental Research and Development Program websites.

Technologies that were considered unproven were not included in the list in Table 12. These are technologies that are theoretical or that have only been tested on a laboratory scale. To be included in Table 12, a technology must have at least been proven effective on demonstration scale in field applications.

A number of technologies were listed by the FRTR as ex situ treatments. These ex situ treatments assume that either (1) contaminated ground water will be pumped out of the subsurface and treated at the surface, or (2) contaminated soil will be excavated and treated at the surface. The ex situ ground water treatments were combined into one listing in the table, and the ex situ soil treatments were considered under the soil removal option.

The existing pump and treat system also was evaluated (Section 4.3).

4.2 Evaluation Criteria

Various types of screening criteria were reviewed, including those used in RCRA CMS. After review of these criteria, consultation with remediation specialists, and review of the remediation objectives listed in Section 3.0, the following criteria were developed for remediation alternatives screening (Table 13).

Table 13. Alternatives Screening Criteria

Criterion 1: Effectiveness	The alternative will meet remediation objectives within a reasonable time frame.
Criterion 2: Implementability	2a: The alternative will be acceptable to the regulators, the STAR Center, and the general public. 2b: The alternative does not adversely affect the health of the building occupants. 2c: The alternative is technically feasible to implement given that (1) all work must be conducted from outside the building, (2) the structural integrity of the building and under-building utilities must be protected, and (3) the alternative must not interfere with business operations inside the building. 2d: The alternative is technically feasible to implement given that contaminant delineation and characterization under the building is limited and that no further characterization is possible. 2e: The alternative is technically feasible to implement given that NAPL may be present under the building and that the location and mass of NAPL are unknown.
Criterion 3: Cost	The cost of the alternative is low, medium, or high relative to the other alternatives that are evaluated.

Criterion 1 evaluates the potential effectiveness of the alternative at the Building 100 Area.

Criterion 2 encompasses a number of different limitations to alternative implementability. Criterion 2a accounts for general acceptability. Criterion 2b directly addresses the protection of the health of the building occupants and was chosen mainly because of the possibility of contaminant vapors passing from the subsurface through the floor of the building into the interior. Criterion 2c concerns the technical feasibility of alternative implementation given that no remediation may be conducted from inside the building. Aspect three of Criterion 2c was

chosen to identify alternatives that may cause electric fields or vibrations that could interfere with normal business operations inside the building. Criterion 2d addresses the very limited information concerning the location of contamination under the building. Criterion 2e addresses the fact that NAPL appears to be present at some locations under the building, but that the exact location and amount of NAPL are unknown.

Criterion 3 was developed to provide qualitative information about cost. This criterion assumes that all work will be conducted from outside the building and that disruption to STAR Center activities must be minimized.

4.3 Evaluation of Existing System

This section evaluates the current pump-and-treat system against the criteria in Table 13. The current pump-and-treat system at the Building 100 Area consists of two recovery wells located near the northwest corner of the building. As discussed in Section 1.4.3, these wells were installed as the final corrective measure for the Building 100 Area, but subsequent ground water characterization demonstrated that the contaminant plume was considerably larger than previously thought.

The two recovery wells have a capture zone that is a maximum of 400 ft in diameter and, therefore, affect only a relatively small area of the known contaminant plume. The wells currently remove approximately 60 pounds of contaminants per year. The estimated dissolved and sorbed mass within the radius of influence of the two recovery wells is 13,500 pounds. If the wells continued mass recovery at the current rate, it would take 225 years to remove all the mass in the area of influence. The estimated mass of the known contaminant plume is 38,000 pounds (including dissolved and sorbed mass, but not accounting for any mass present as NAPL), so the two wells remove less than 0.2 percent of the total plume mass in a year. Based on the current recovery rates and the estimated contaminant mass, clearly the two recovery wells are not an effective remedial option.

An estimate of time required for contaminants to be transported from the recovery wells to the monitoring wells at the southeast corner of the building was conducted. Ground water at the Building 100 Area has been estimated to move at a maximum velocity of 6 ft/year. Using this rate, the estimated conservative contaminant travel time from RW01 to well 0514 is 160 years. However, the contaminant velocity is retarded relative to ground water velocity due to the contaminant's tendency to sorb to the aquifer matrix, so actual travel times would be longer. This demonstrates that cessation of pumping from these two recovery wells would have no effect on contaminant concentrations at and downgradient from the southeast corner of the building within a reasonable time period. As discussed in Section 1.4.3, these wells were installed to treat a localized contaminant plume at the northwest corner of the building, before additional characterization defined a larger extent of contamination.

The most recent plan for remediation (the 1998 CMIP Addendum) included the potential for adding two more recovery wells near the southeast corner of the building. These wells likely would have a capture zone similar to that of the two existing recovery wells, but the plume is much more dilute in this area, leading to a considerably lower mass recovery rate. While these wells would provide some measure of plume control, they, in combination with the two existing recovery wells, would not be an effective remedial option for the entire plume. In addition,

control of the plume is not necessary, based on the stability of the plume as described in Section 2.3.

Clearly the current pump-and-treat system fails to meet Criterion 1. The two recovery wells affect only a small part of the contaminant plume, and therefore it is not possible for the current system meet the remediation objectives for the entire plume at the Building 100 Area. Criterion 2 (implementability) does not apply to the current system because it has already been implemented. Cost under Criterion 3 would be high because the system would continue to operate while never meeting the remediation objectives.

4.4 Evaluation of Alternative Active Remediation Systems

The criteria in Table 13 were used to evaluate the active remediation alternatives listed in Table 12. Assumptions and explanations for the evaluation are as follows.

- Unproven technologies were not included in Table 12. A technology must have been proven effective on a demonstration scale in field applications to be included. Theoretical technologies or those tested only in the laboratory were not considered.
- All remediation activities must be conducted from outside the building. Access to areas under the building generally would be accomplished using horizontal wells.
- Combinations of primary and secondary remediation technologies were not specifically listed in Table 12, but were considered during the evaluation. For example, fracturing could aid in delivery of an amendment such as a chemical oxidant.
- Treatment trains of primary remediation technologies also were considered during the evaluation. An example of a treatment train is thermal NAPL remediation followed by polishing of the remaining low levels of contamination by enhanced bioremediation.
- Ex situ treatment technologies, wherein contaminated media are treated at the surface following removal from the subsurface, are considered with the technology used to remove the contamination from the subsurface. For example, surface treatment of ground water using air stripping was included in the evaluation of pump and treat.
- Some technologies obviously were not applicable, and therefore were not evaluated in detail under the criteria. An example of this is bioslurping.
- Pump and treat is listed twice in Table 12, once in the physical treatment category and once in the containment category.

The result of the evaluation of each alternative is summarized in the “Conclusions” column in Table 12. A general discussion of the evaluation is presented in the following text.

The lack of characterization and probable NAPL presence caused most alternatives to fail to meet Criterion 1. If the extent and amount of contamination is unknown, the time required for remediation is impossible to predict.

Most alternatives failed Criterion 2a in that they would be unacceptable to the STAR Center because of the negative impacts listed under Criterion 2c. A few technologies failed Criterion 2b because their implementation could produce contaminant vapors that potentially intrude into the building. Most technologies failed Criterion 2c because working from outside the building would

have a significant negative impact to business operations due to potential long-term blocking of roadways, sidewalks, and parking lots. Parking around the building currently is near capacity, and any reduction to the amount of available parking would negatively impact employees and visitors, potentially causing loss of tenants. In addition, implementation from outside the building involves working around the numerous existing infrastructure components such as buildings, roadways, and underground utilities.

Every alternative failed to meet Criteria 2d and 2e. Simply stated, it is not feasible to implement any active remediation under an 11-acre building when the location and mass of contamination is unknown. The potential presence of NAPL in unknown amounts and locations exacerbates the problem. While there certainly are some known contaminant concentrations for a few locations under the building, this information is insufficient for designing a remediation system. In addition, characterization using wells or borings through the floor of the building is not possible because of the full utilization of all areas of the building by tenants. Additional characterization from outside the building is not feasible due to the negative impacts to site activities (blocking roads and sidewalks, etc.) and the high cost of installing horizontal wells or soil borings at multiple locations and depths under the large building.

Under Criterion 3, most alternatives were determined to have a high cost. This is due to the uncertainty associated with the lack of knowledge of contaminant mass and extent, the fact that the building is very large, the requirement that work be conducted from outside the building without interfering with business operations, and the need to work around the significant infrastructure outside the building.

In summary, no active remediation technology or combination of technologies, including the current pump-and-treat system, meets all the criteria listed in Table 13. No technology can meet MCLs given the poor characterization and delineation of contaminants under the building and the unknown mass of contamination. Additionally, the significant negative impacts to the STAR Center and high costs of working from outside the building preclude the application of any active remediation technology.

5.0 Risk Management Options

The evaluation in Section 4 indicates that continued operation of the existing treatment system or an alternative active remediation system will not meet the remediation goals. The original goal of achieving MCLs and restoring the site for unrestricted use is unrealistic. Therefore, other risk management options must be considered.

5.1 Background

The State of Florida's Contaminated Site Cleanup Criteria (Chapter 62-780) identify three "risk management options" (RMOs) that represent the possible regulatory endpoints for contaminated site cleanups. From a practical standpoint, the two main outcomes of those RMOs are either "No Further Action Without Controls" or "No Further Action With Controls." Controls are considered to be either engineered features or administrative mechanisms that reduce or eliminate the migration of and/or exposure to contamination. A slurry wall is an example of an engineering control; a deed restriction is a type of institutional control. The need for a control is

largely dictated by the cleanup goals that have been attained for a site and whether any residual contamination remains following completion of remediation activities.

As noted in Section 1.3, the HSWA permit for the site indicates that final ground water cleanup criteria for the Building 100 Area must be either background, promulgated federal and state standards, state cleanup criteria, or alternate risk-derived target cleanup levels. The CMS (DOE 1994) for the Building 100 Area ground water proposed state drinking water MCLs as cleanup criteria, which have commonly been used as default cleanup criteria for numerous contaminated ground water sites across the country. The ground water remediation system at the Building 100 Area was installed and operated with the achievement of MCLs as the ultimate cleanup goal. However, as discussed in Section 4.0, the complexity of the site makes it highly unlikely that the current remediation system or any reasonable alternative will be able to attain that goal.

With the State of Florida's recent emphasis on implementing risk-based cleanups, a comprehensive exposure pathway evaluation was conducted for the Building 100 Area with emphasis on identifying potentially complete exposure pathways to contaminated ground water (see Section 2.5). Based on current site conditions, there are no complete pathways to site-related contamination. Current contaminant concentrations in the subsurface pose no present or future threat to on-site or off-site receptors if current land and water uses are maintained. The on-site plume appears to be stable or shrinking, and natural biodegradation processes will only cause this attenuation to continue. The only potentially unacceptable risks would be through use of on-site ground water as a potable water source.

5.2 No Further Action Without Controls

Under this option, remediation would be discontinued and the remediation system decommissioned. Some residual ground water contamination would remain. No controls would be put in place to restrict ground water use. Though it is unlikely that current or future property owners would want to use the shallow, contaminated aquifer, no formal mechanism would prevent this use. Therefore, this risk management option would not provide adequate assurance of protection of human health.

5.3 No Further Action With Controls

Under the No Further Action With Controls option, the existing remediation system would cease to operate and no further active remediation would occur. As discussed in Section 2.3.4, natural degradation processes would continue to occur in the subsurface through time, and the contaminant plume would be expected to shrink and eventually degrade completely. Contamination is and would continue to be present beneath Building 100 at concentrations that would preclude unrestricted use of on-site ground water for some time into the future. However, as noted in Section 2.4, if current land and water uses were to remain in effect in the future, no complete exposure pathways to contamination would be present.

The STAR Center has been designated a Brownfields site by Pinellas County, which is an acknowledgement that some contamination will remain at the site, but given likely future uses, this contamination will not present an unacceptable risk. Presently, Building 100 and surrounding infrastructure (e.g., buildings, parking lots, and roads) serve, in part, as engineering

controls that prevent migration of and exposure to contaminants, particularly volatile constituents. Formal ICs, as permitted under Florida law, would be put in place under this alternative to prevent inappropriate future water or land use. Permission of the property owner(s) would be obtained, and public notification, as appropriate, would be required as well (FDEP 2004).

The restrictions placed by the IC would prohibit installation of wells (excluding monitoring wells) to depths of less than 100 ft and would prohibit excavations to depths greater than 10 ft. It is likely that the IC would be legally recorded as a restrictive covenant on the property. Once approved and recorded, a copy of the IC will be included in the long-term monitoring plan for the site, which details long-term requirements for the site to be carried out by DOE's Office of Legacy Management. The Pinellas site was officially transferred into DOE's Legacy Management program in 2004. Besides including requirements for ground water monitoring at the site, the long-term monitoring plan will also require monitoring the effectiveness of ICs at the site and any changes in the use of Building 100 (e.g., demolition or renovation of all or parts of the building). This monitoring will ensure that No Further Action With Controls continues to be protective of human health and the environment.

Monitoring of the ground water would continue at the site for an indefinite period. The specific type of ICs and control boundaries, ground water points of compliance, compliance criteria, and monitoring details would also be spelled out in the long-term monitoring plan for the site.

When the final remediation alternative is fully implemented, ICs will be placed on the site property that will prevent inappropriate ground water use. MCLs for site-related COPCs will be applied as ground water cleanup goals outside the institutional control boundary. This approach is consistent with EPA's RCRA ground water guidance where containment of the plume is the final ground water goal rather than meeting cleanup levels throughout contaminated ground water plume (EPA 2004). As long as the contaminant plume remains stable and MCLs are maintained outside the IC boundary, on-site contaminant concentrations are acceptable. Therefore, no numerical cleanup goals are necessary for on-site ground water. This approach is consistent with EPA's RCRA guidance (EPA 2004) for sites where ground water containment, rather than complete plume restoration, is the long-term cleanup objective.

The DOE Office of Legacy Management was created specifically for long-term stewardship of DOE properties and former DOE facilities, many with radioactive components that require surveillance for decades. DOE has the robust infrastructure and proven experience with developing, implementing, and monitoring ICs for long periods of time. For these reasons and the reasons discussed previously in this section, the No Further Action With Controls option is readily implementable. ICs will be effective at preventing unacceptable exposures given plume stability and current and potential future land uses. No Further Action With Controls is adequately protective of any current or future human health and ecological risks. Application of No Further Action With Controls for the Building 100 area is consistent with RMO III under FDEP's Contaminated Site Cleanup Criteria.

6.0 Summary and Recommendations

Changed conditions at the Pinellas site Building 100 Area since completion of the original CMS report necessitated a reevaluation of remediation objectives and alternatives for the site. Changes in site conditions included:

- Transfer of property ownership from DOE to Pinellas County for use as an industrial park;
- Fundamental changes in the conceptual site model for the site (see below) based on collection of additional characterization data;
- A change in the regulatory framework for the site with the recent promulgation of Global RBCA by FDEP.

Operation of the active remediation system along with collection of additional characterization indicates that the contaminant plume is larger than initially believed. In addition, it is possible that isolated pockets of NAPL exist in the area, particularly below Building 100. However, the presence of Building 100 and associated infrastructure, as well as on site uses and activities, has precluded detailed site characterization. Despite these constraints, the following can be concluded about the site:

- The dissolved-phase ground water contaminant plume is stable, likely due to the extremely low ground water flow velocity and ongoing naturally occurring, robust biodegradation processes documented at the site.
- The potential presence of NAPL does not negatively impact plume stability.
- There has been no significant impact on resources by contaminants.
- There are no current or future complete human or ecological exposure pathways as long as existing land and water uses are maintained.

Active remediation technologies, including the existing recovery and treatment system, were evaluated based on effectiveness, implementability, and cost. The evaluation indicated the following:

- The existing ground water recovery and ex situ treatment system does not make a significant contribution to either contaminant plume stabilization or contaminant mass removal and, therefore, does not reduce risk.
- None of the other known active remediation alternatives is considered viable due to the presence of Building 100 and surrounding infrastructure, and due to inadequate contaminant characterization and delineation.
- Supplementing the existing ground cover (which serves as a de facto engineering control) with properly developed and implemented ICs and long-term monitoring can meet remediation objectives and ensure that there is no potential contaminant exposure in the future.

While DOE's original remediation objective was to meet MCLs throughout the contaminant plume, this goal does not appear to be reasonable given current knowledge of the site. Containment of the plume has been achieved and is determined to be effective at protecting human health and the environment at the site. Based on the reevaluation of the Building 100

Area site conditions in the light of the current regulatory framework, it has been concluded that No Further Action with Controls is the only viable alternative for the Building 100 Area.

In order to implement this option, DOE proposes that ICs be placed on the site property to prevent inappropriate ground water use, and that MCLs for site-related COPCs be applied as ground water cleanup goals outside the IC boundary. This approach is consistent with EPA's RCRA guidance for plume containment sites (EPA 2004). As long as the contaminant plume remains stable, MCLs are maintained outside the IC boundary, and no complete exposure pathways exist, on-site contaminant concentrations are acceptable.

Because the two existing ground water recovery wells do not contribute significantly to either contaminant plume containment or mass removal, DOE proposed shutting down these wells and associated treatment system.

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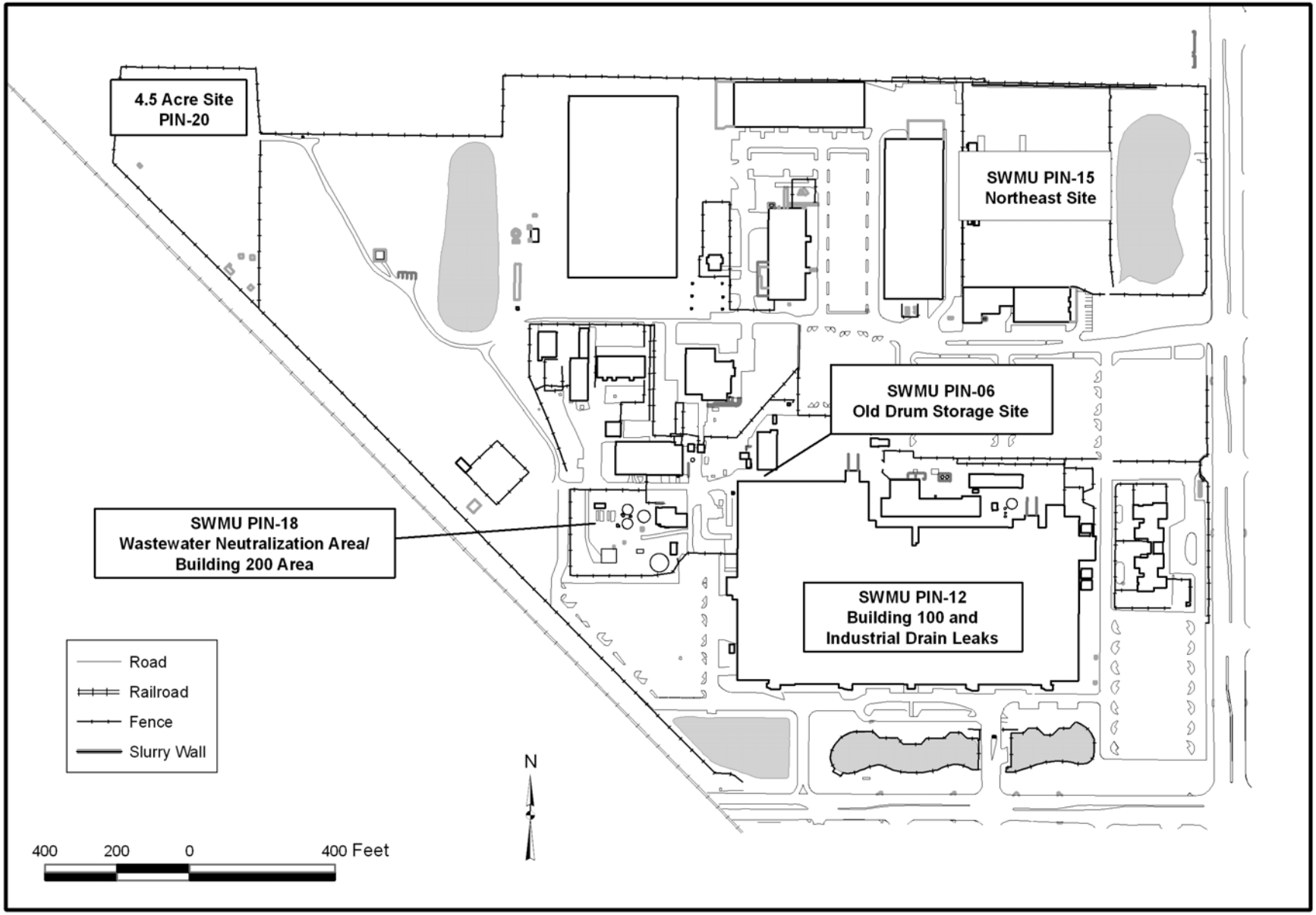

Figure 1. Location of PIN06 and PIN12

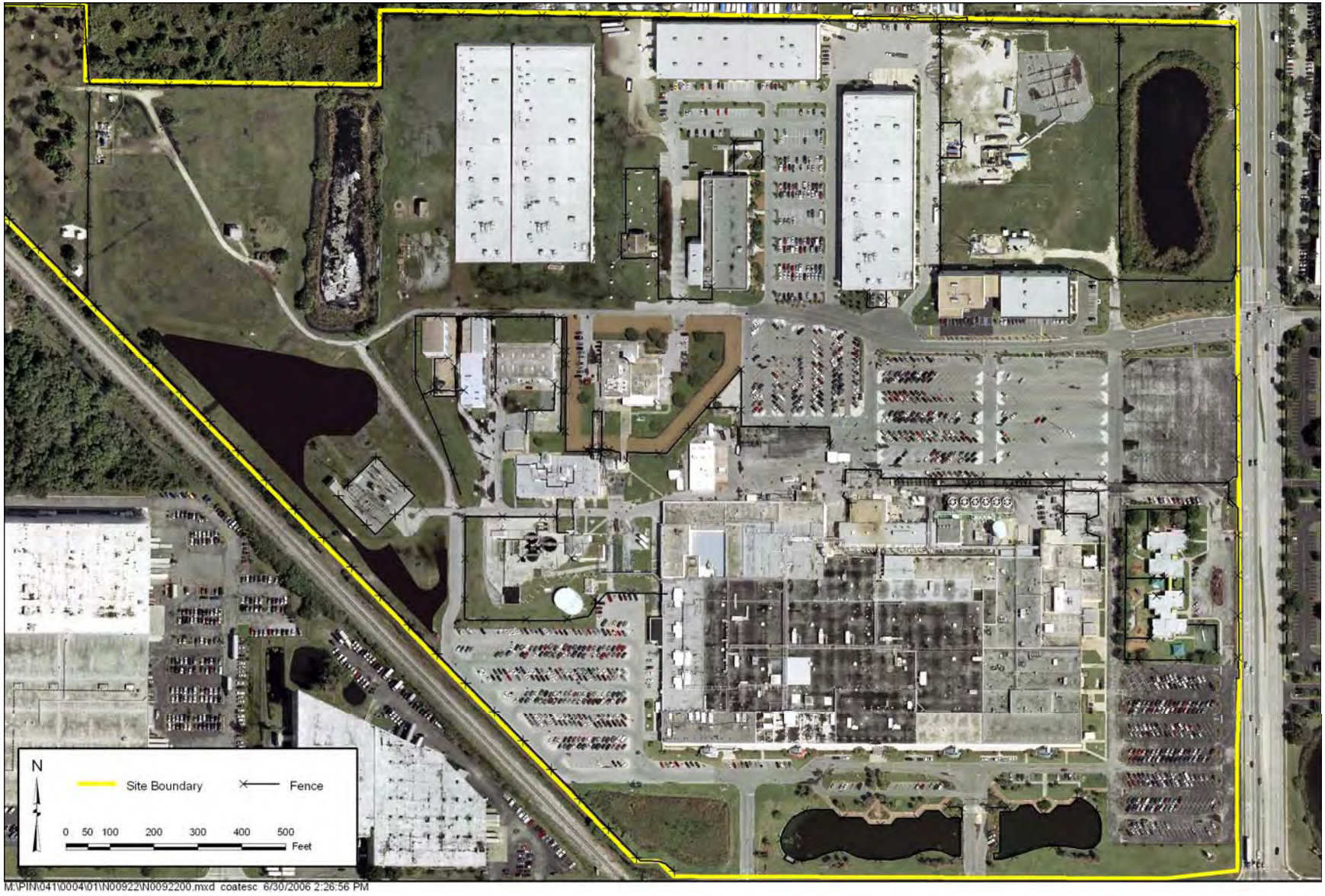

Figure 2. Air Photo of STAR Center

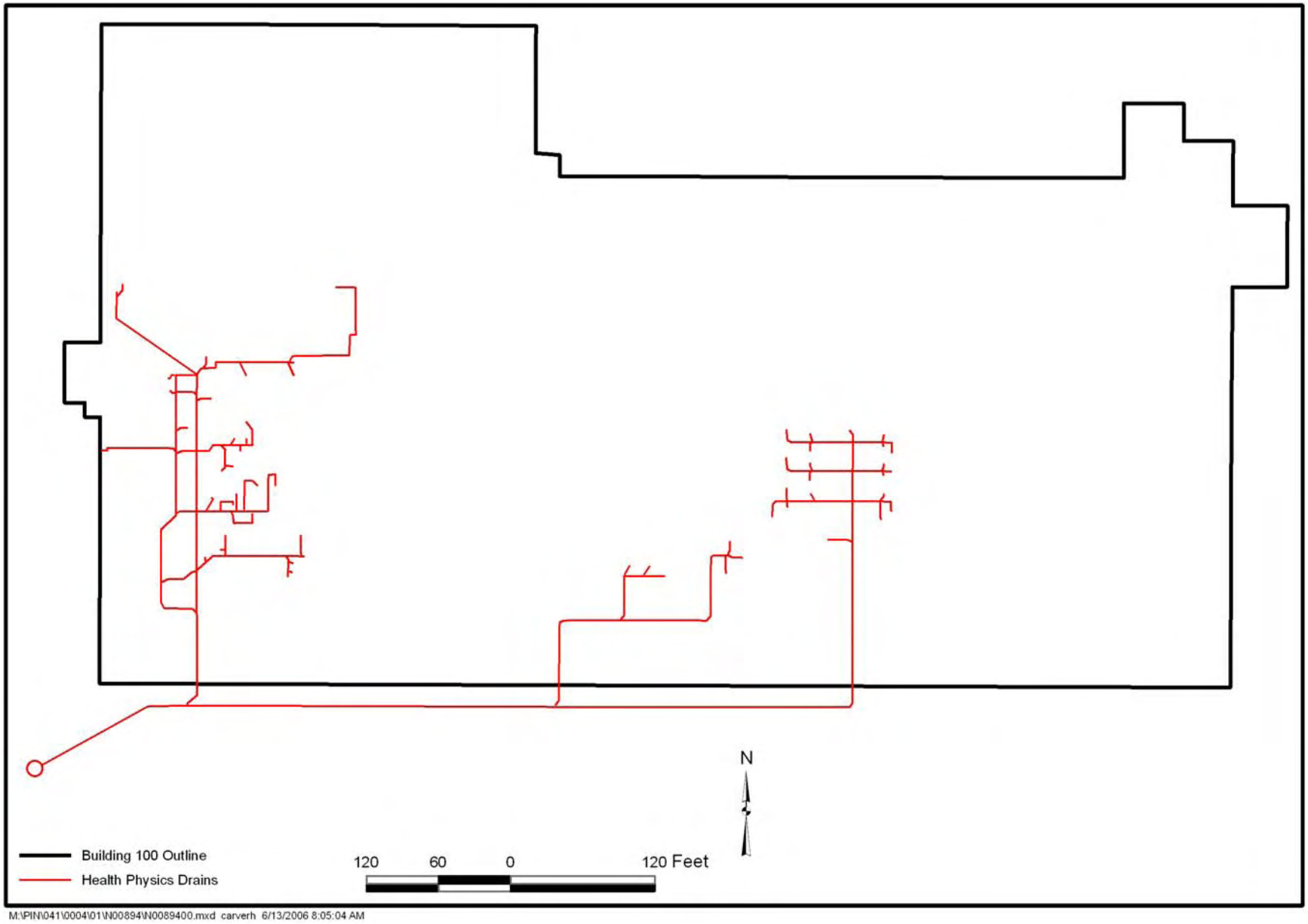

Figure 3. Building 100 Health Physics Drain System

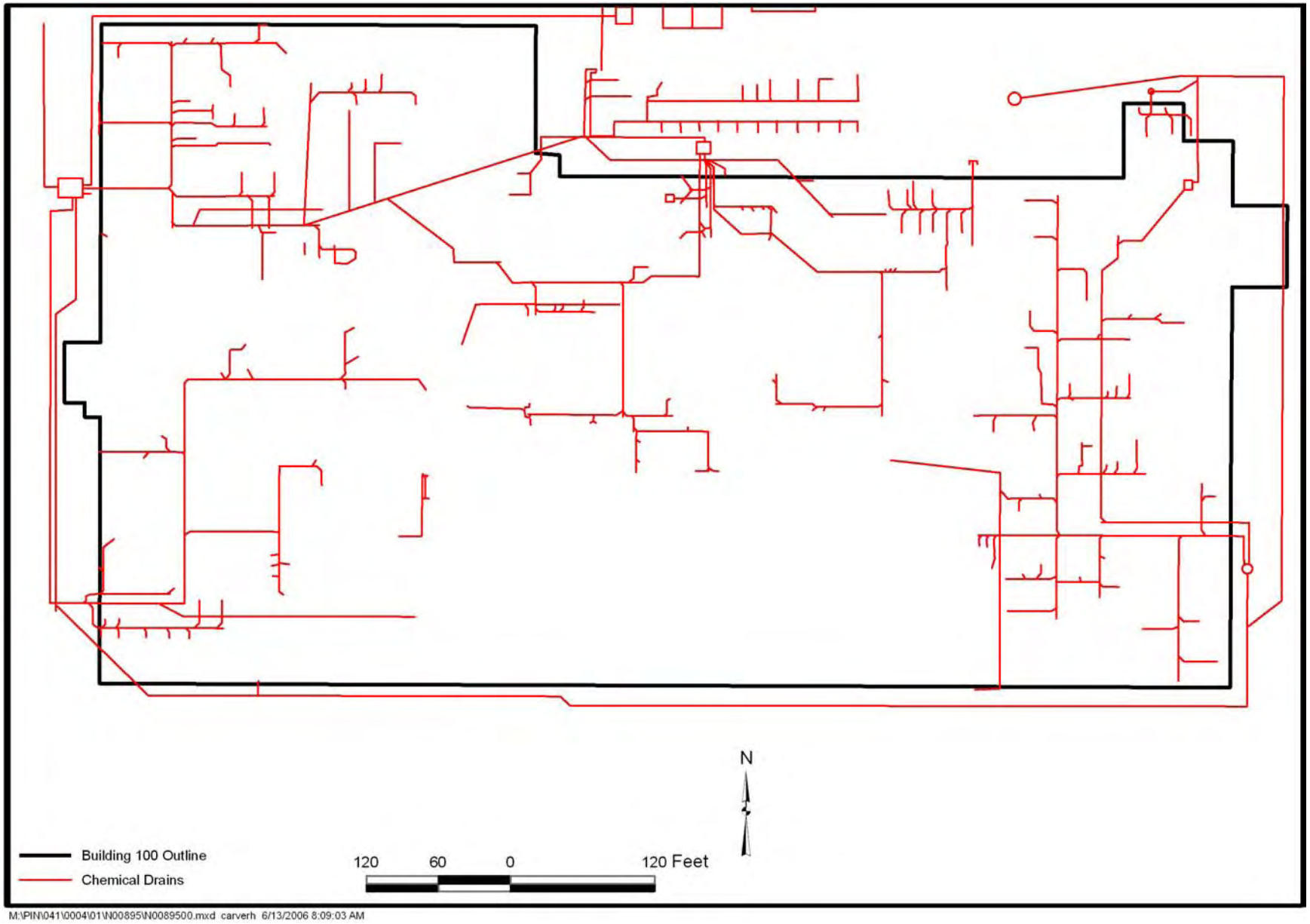

Figure 4. Building 100 Chemical Drain System

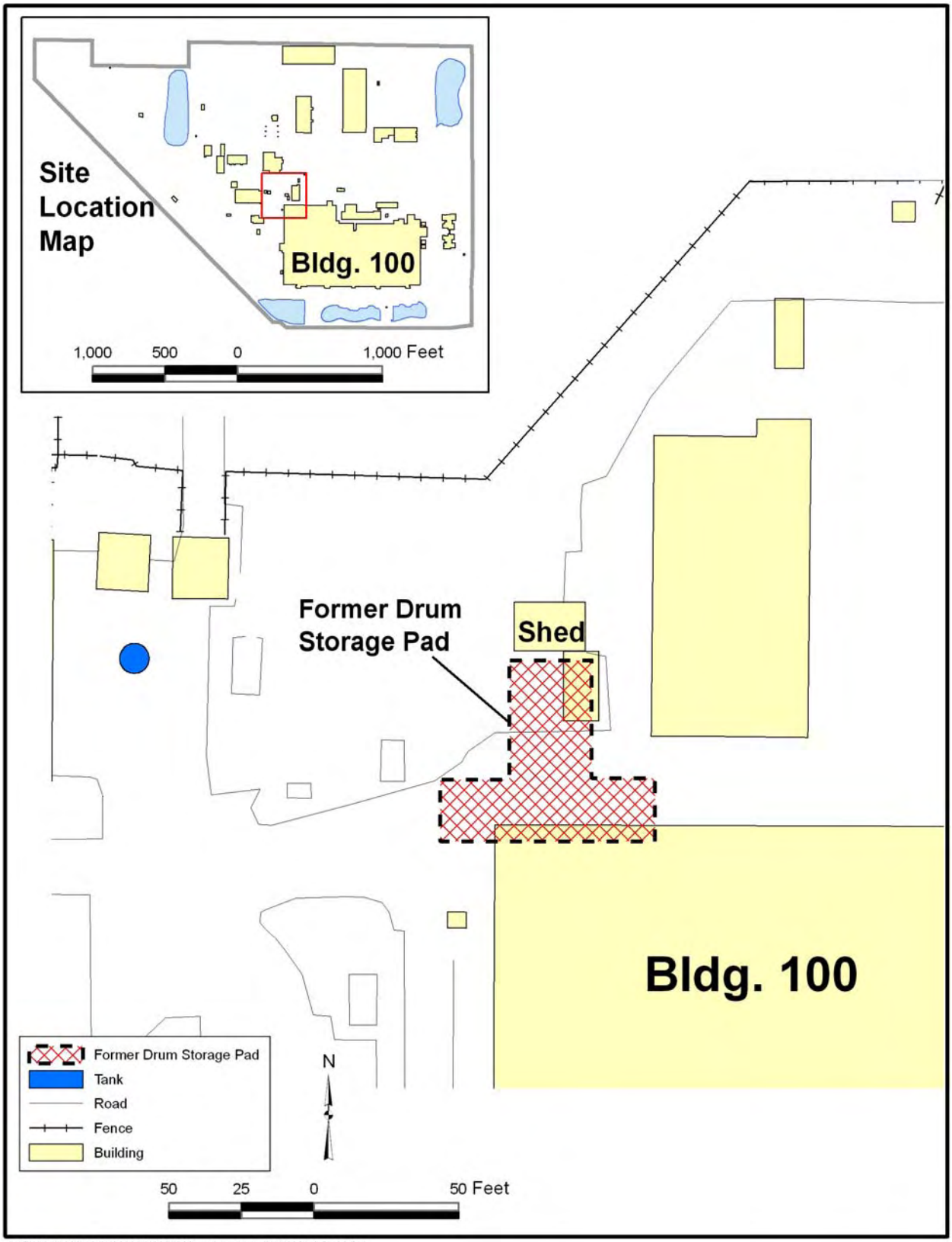

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Figure 5. Location of the Old Drum Storage Area

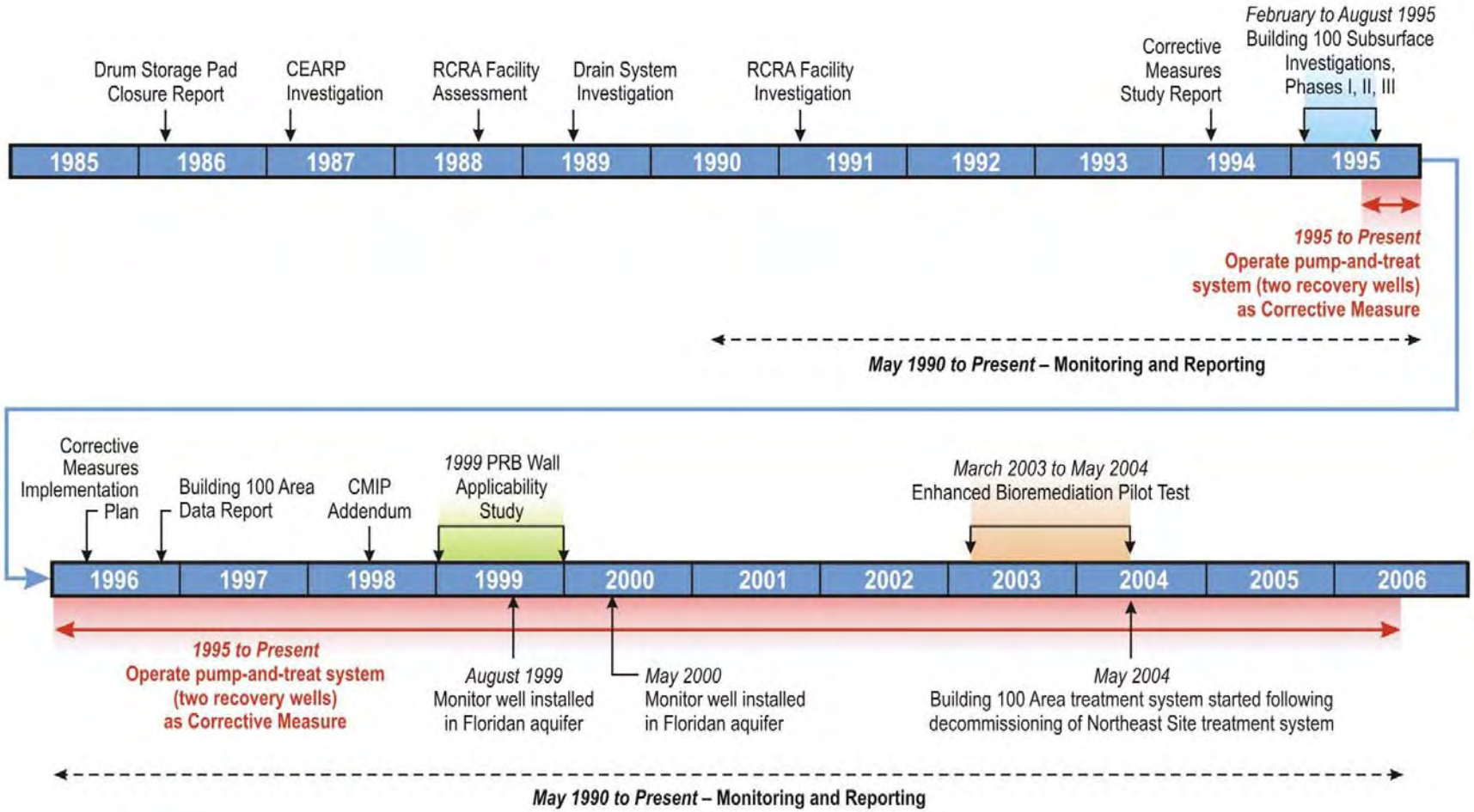

Figure 6. Building 100 Area Documentation and Remediation Activities Timeline

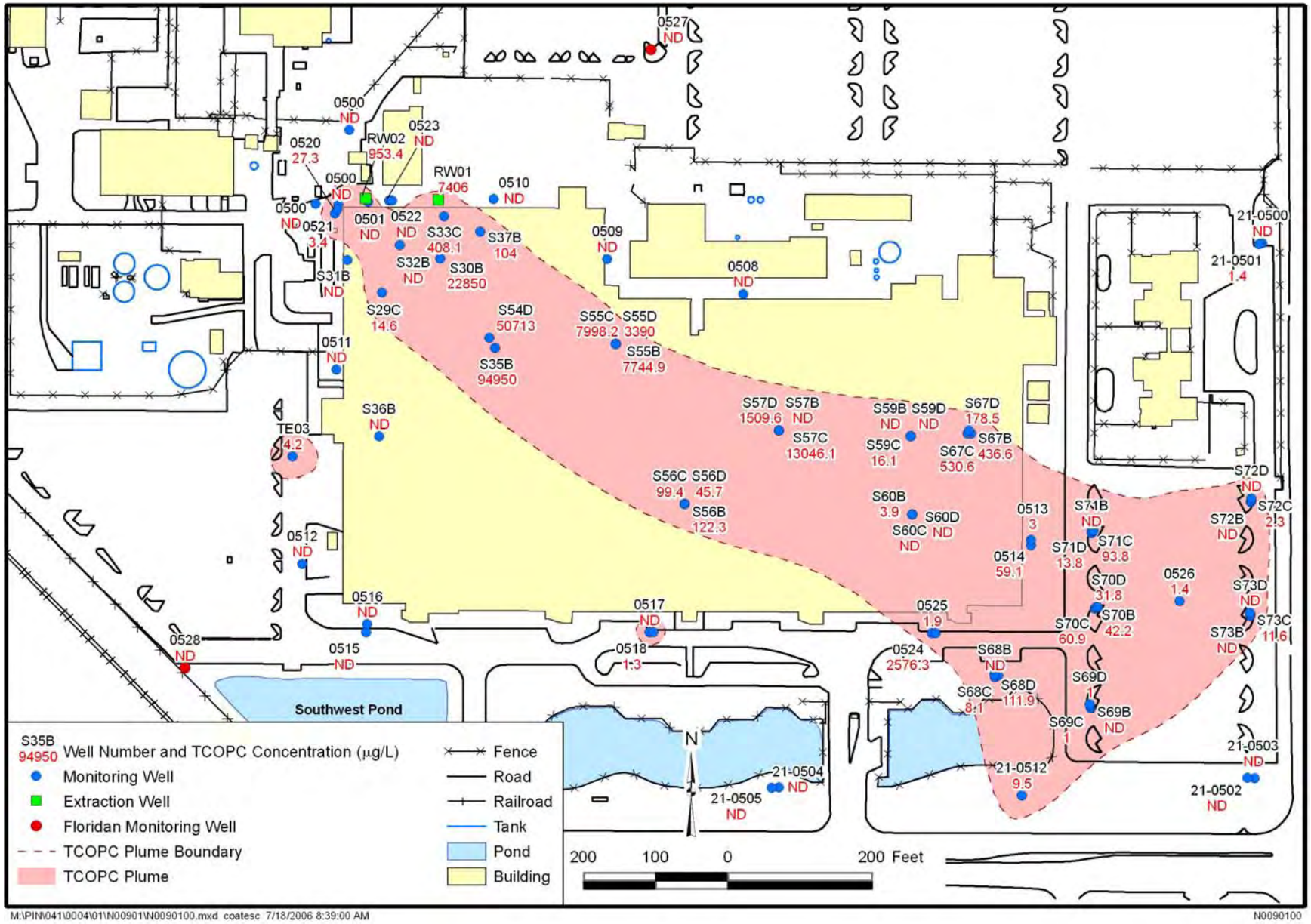

Figure 7. Total COPCs Plume at the Building 100 Area

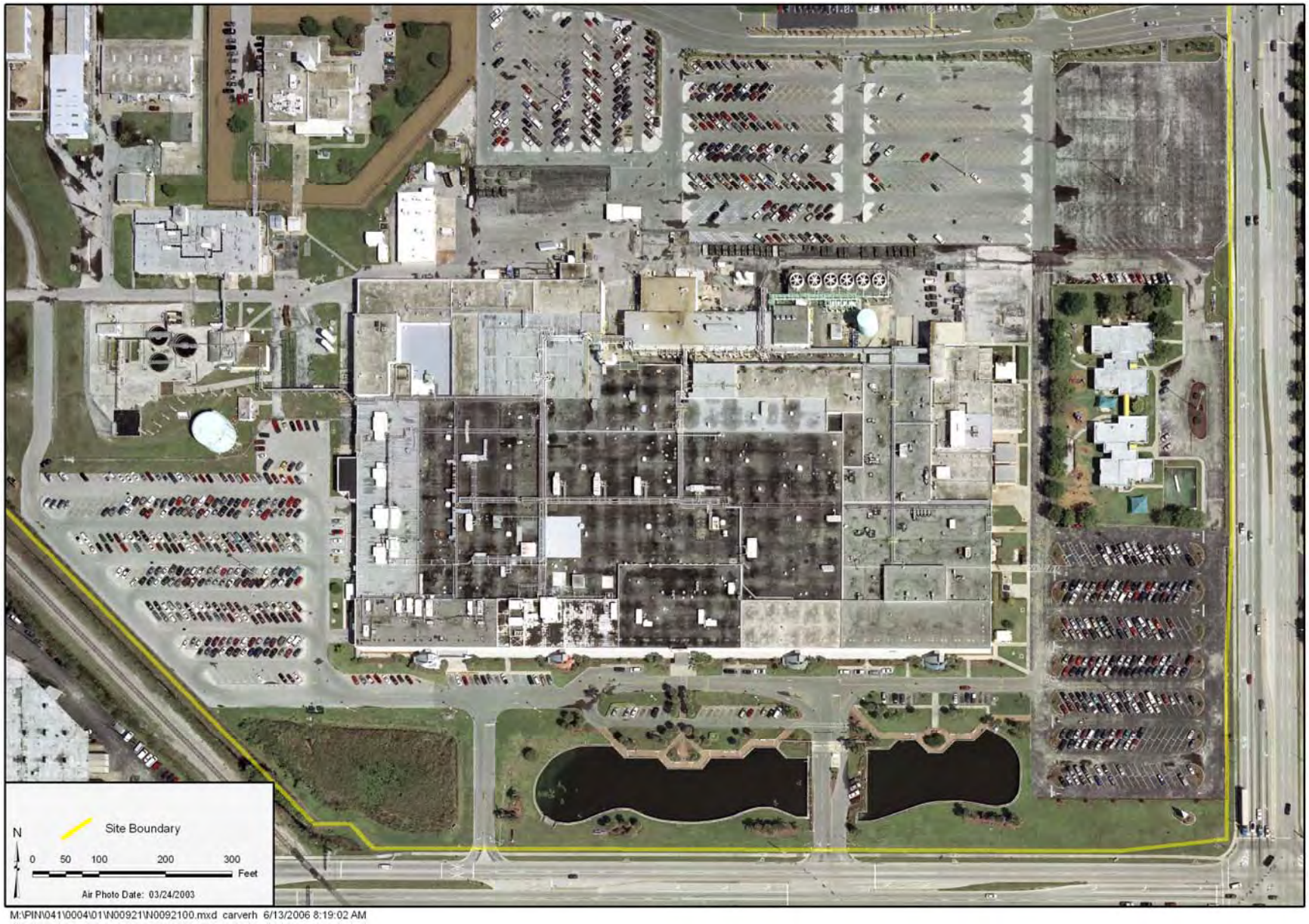

Figure 8. Air Photo Showing the Building 100 Area

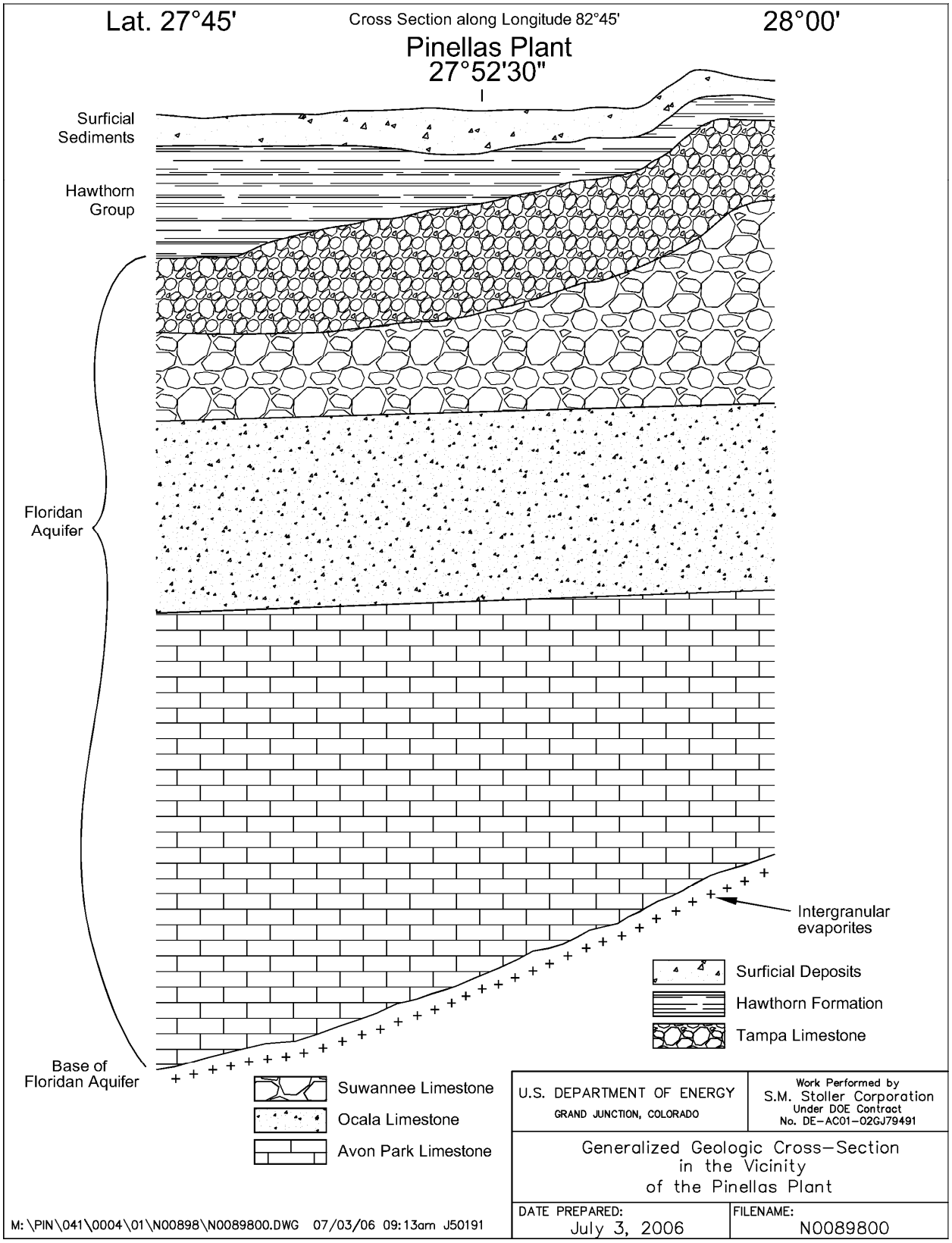

Figure 9. General Geologic Cross Section of the STAR Center Area

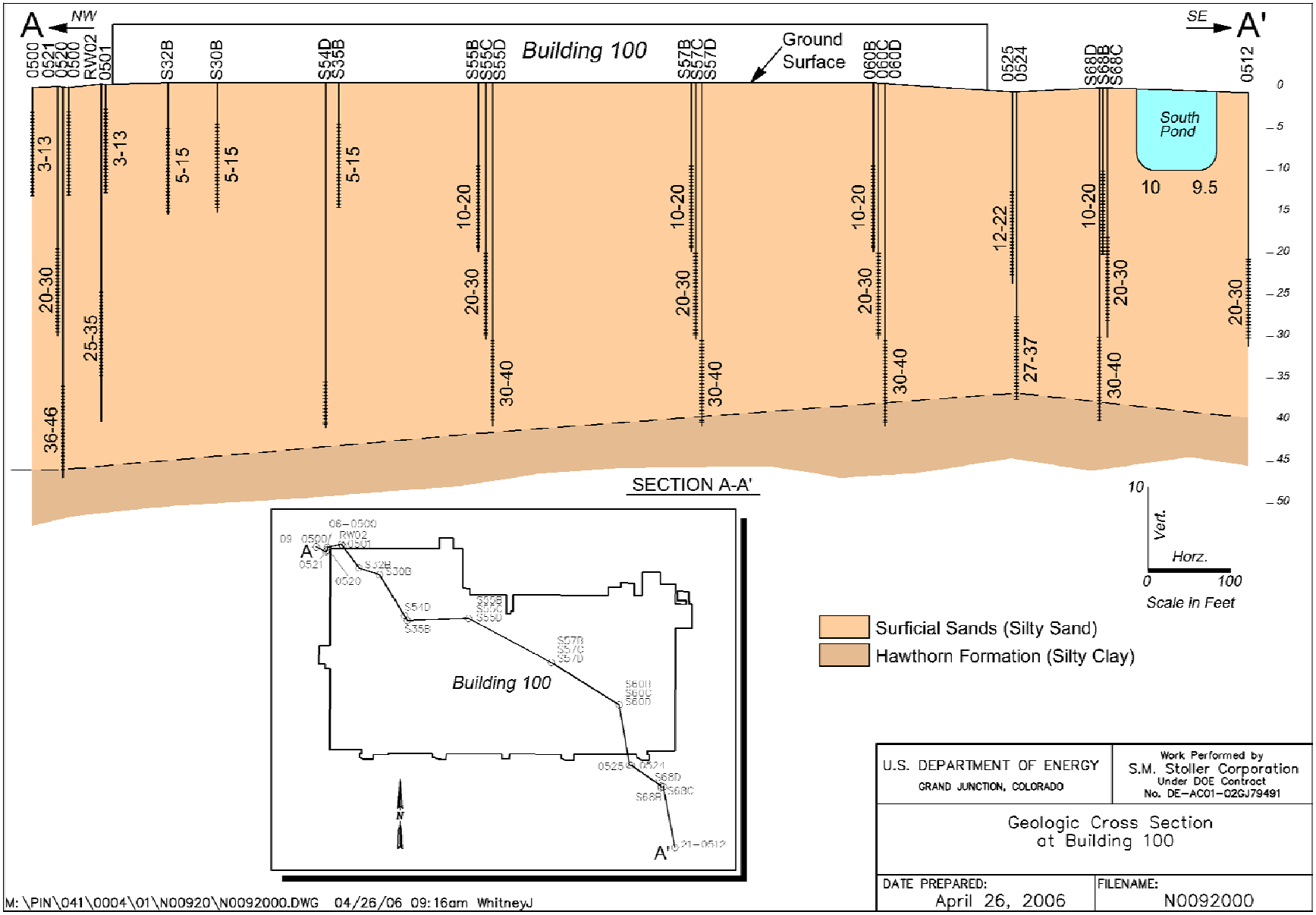

Figure 10. Geologic Cross Section of the Building 100 Area

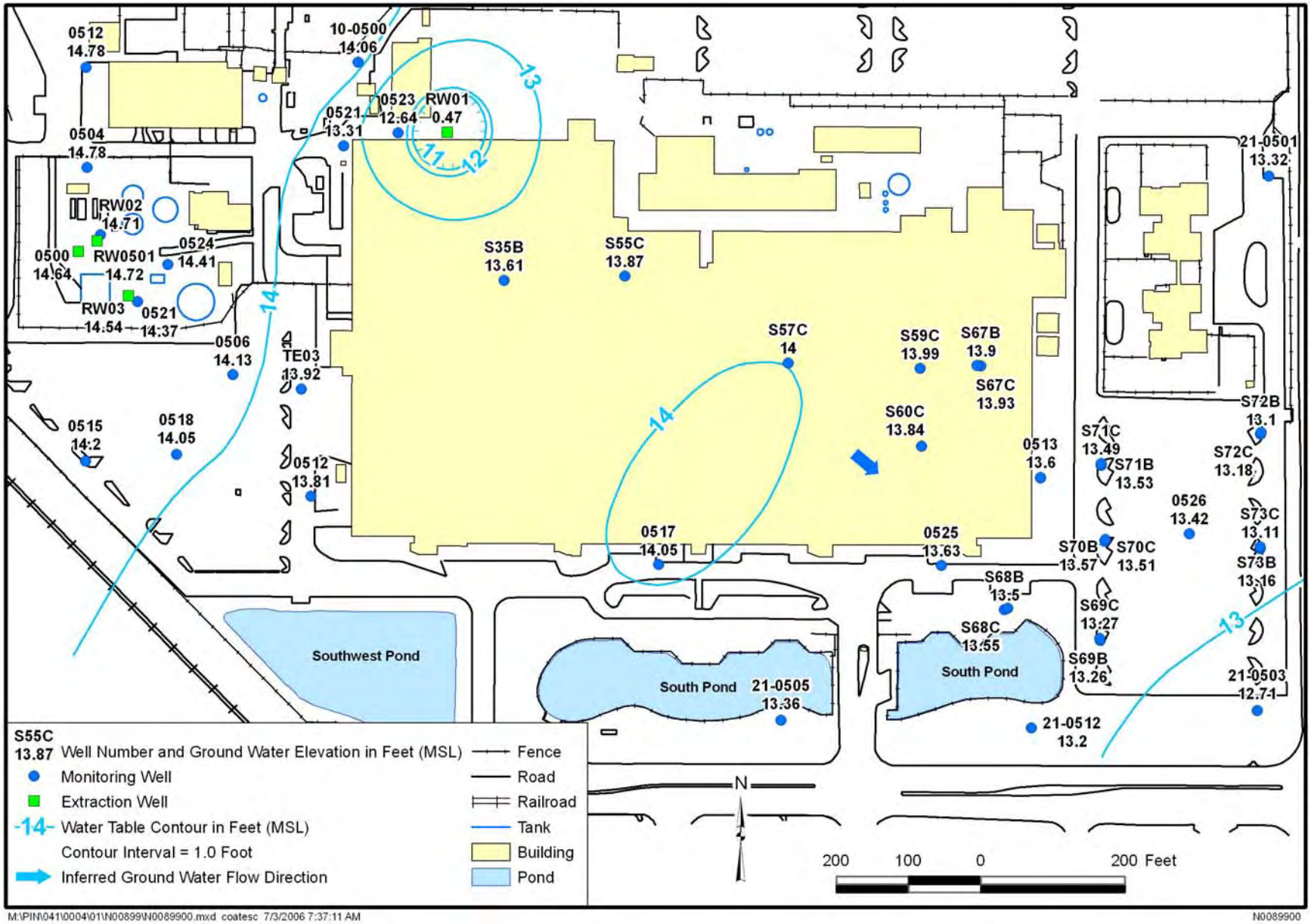

Figure 11. Ground Water Elevations and Flow Direction in the Shallow Surficial Aquifer at the Building 100 Area in March 2006

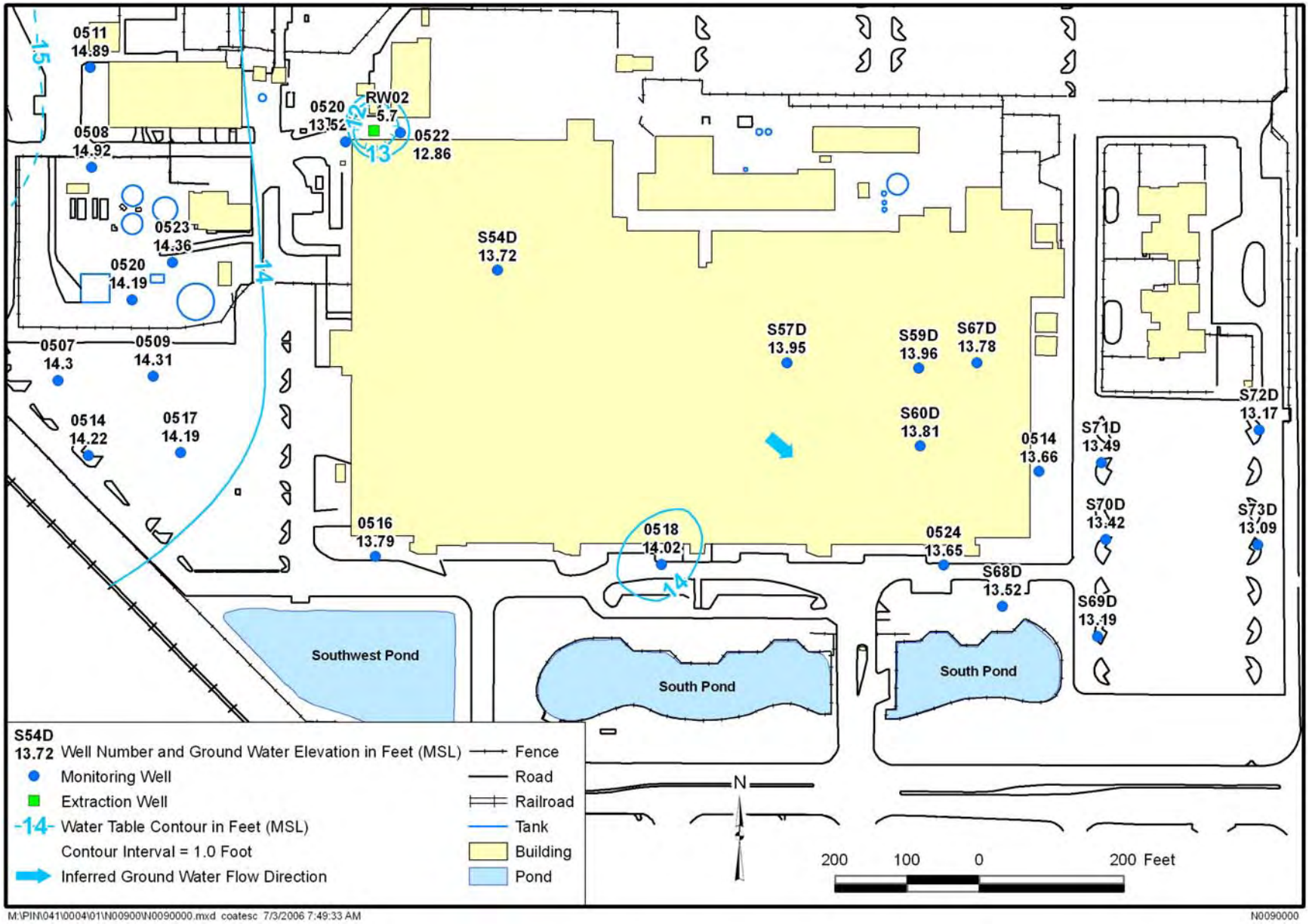

Figure 12. Ground Water Elevations and Flow Direction in the Deep Surficial Aquifer at the Building 100 Area in March 2006

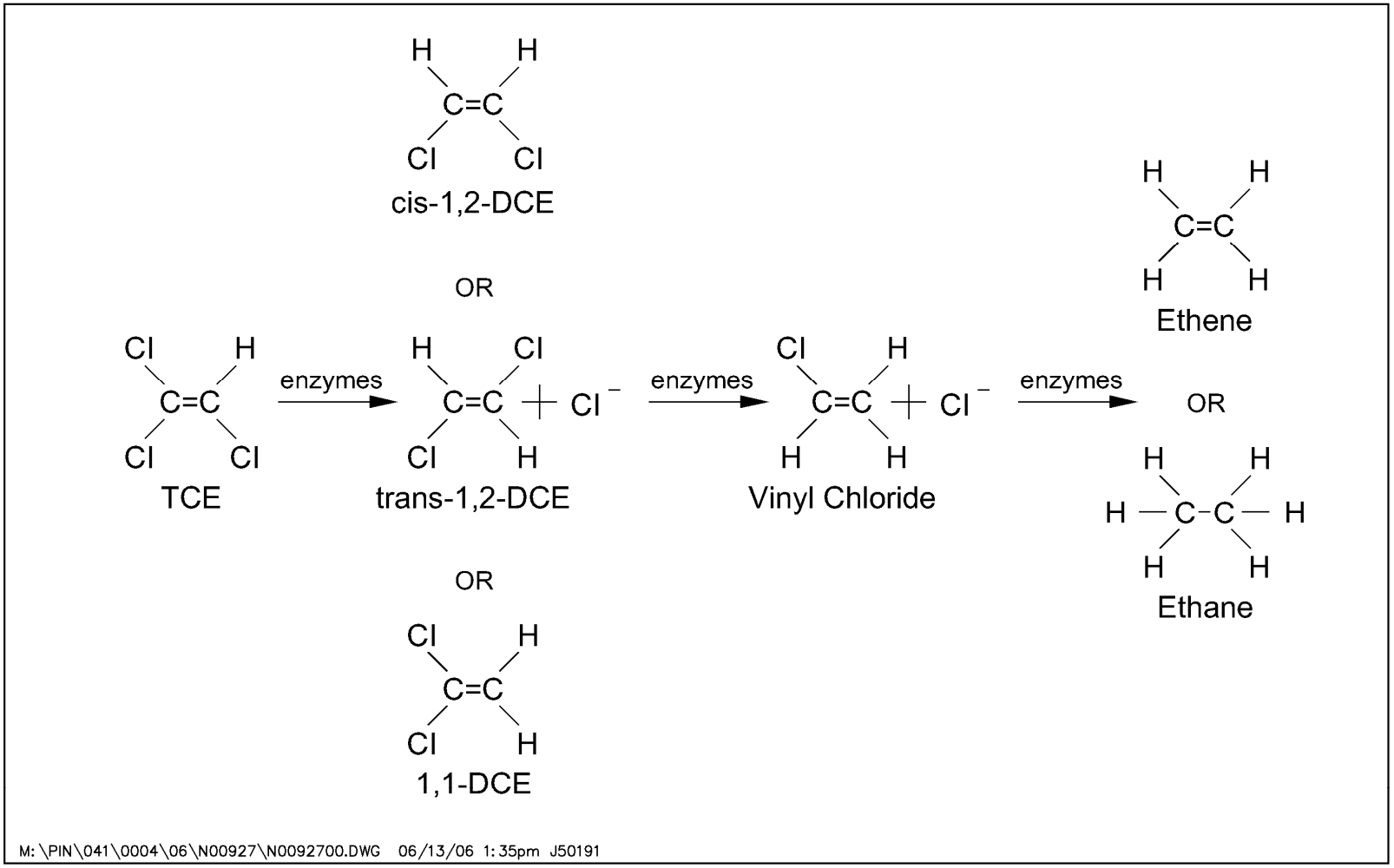

Figure 13. TCE Degradation Pathway

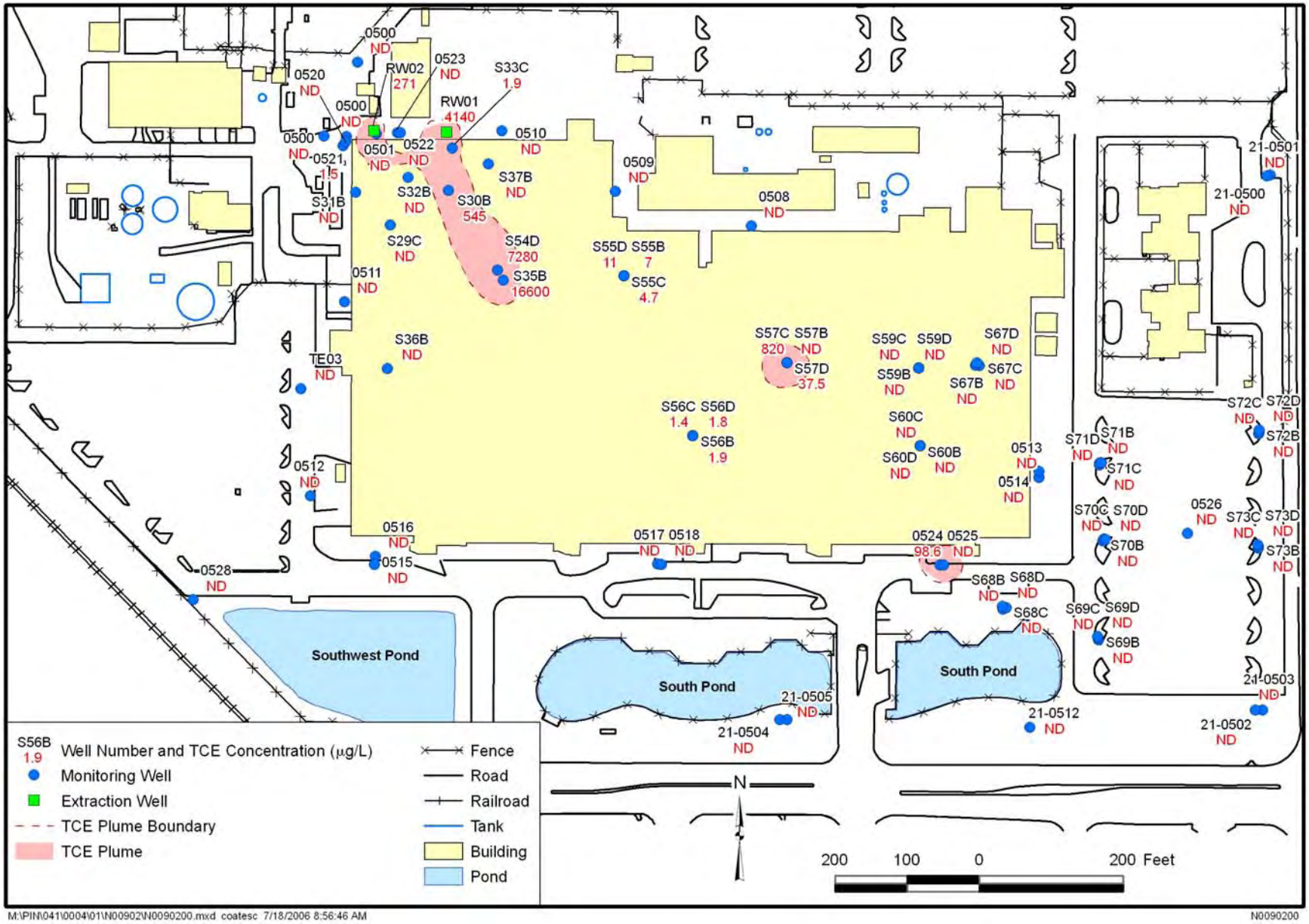

Figure 14. TCE Plume at the Building 100 Area

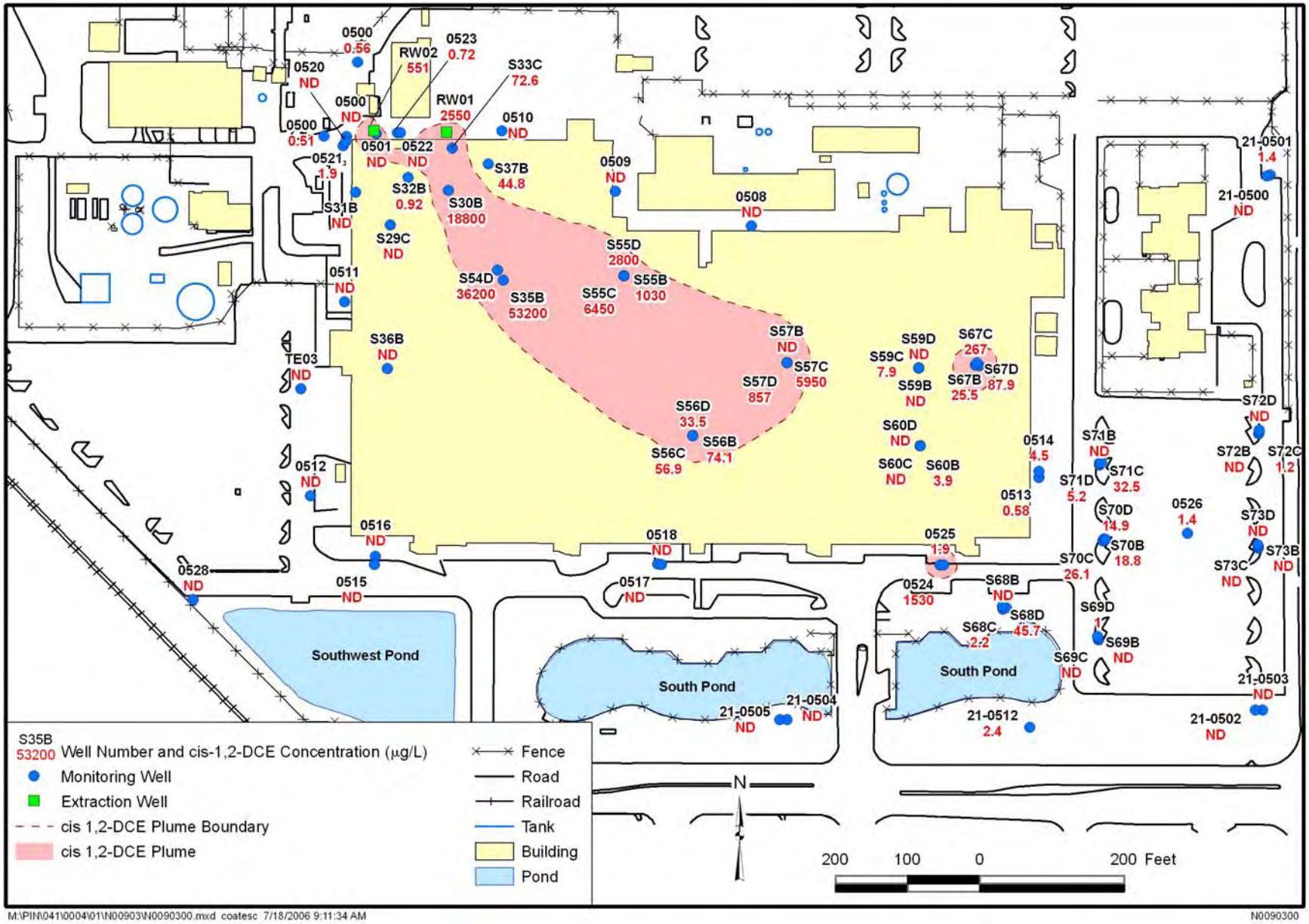

Figure 15. cis-1,2-DCE Plume at the Building 100 Area

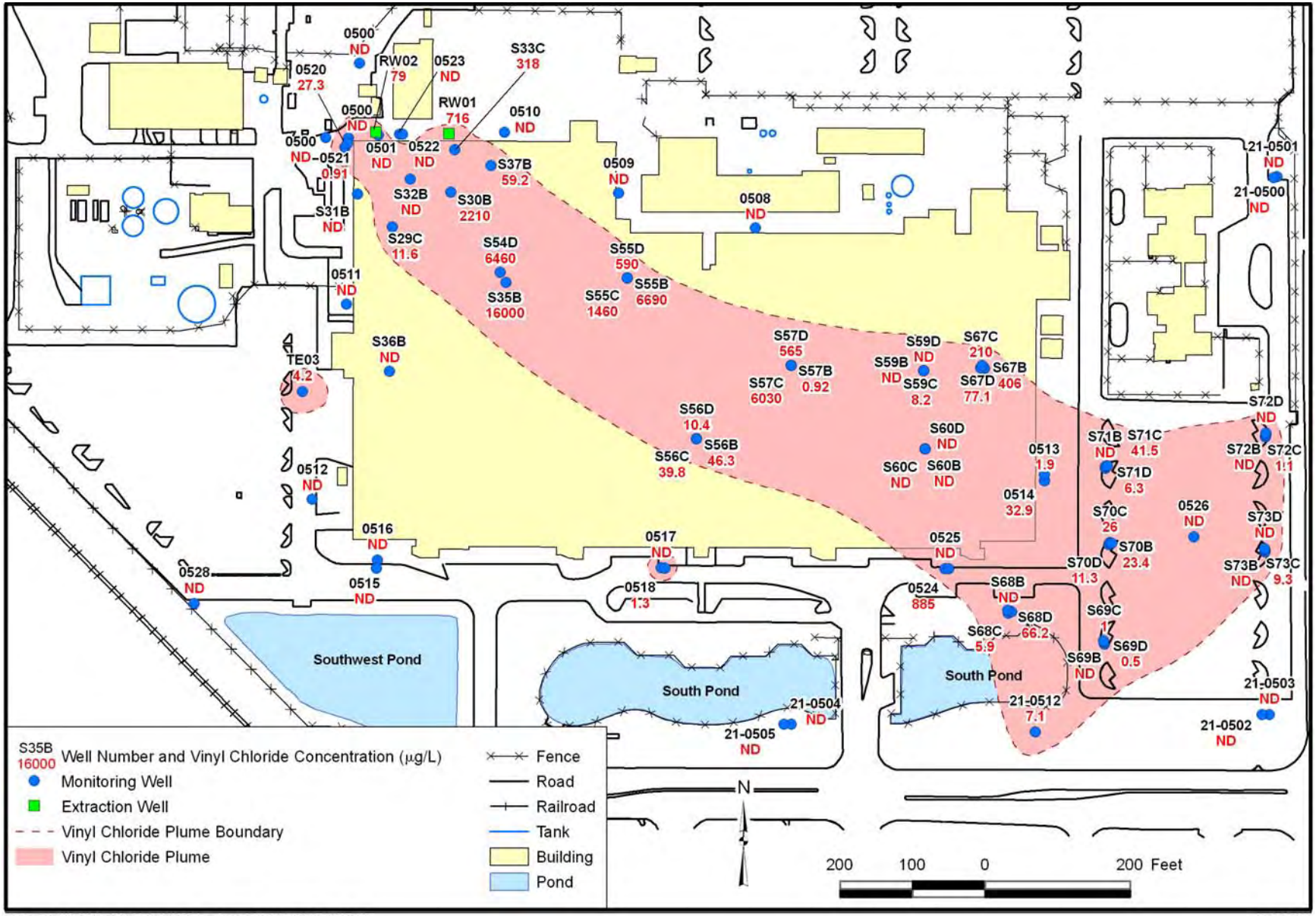

Figure 16. Vinyl Chloride Plume at the Building 100 Area

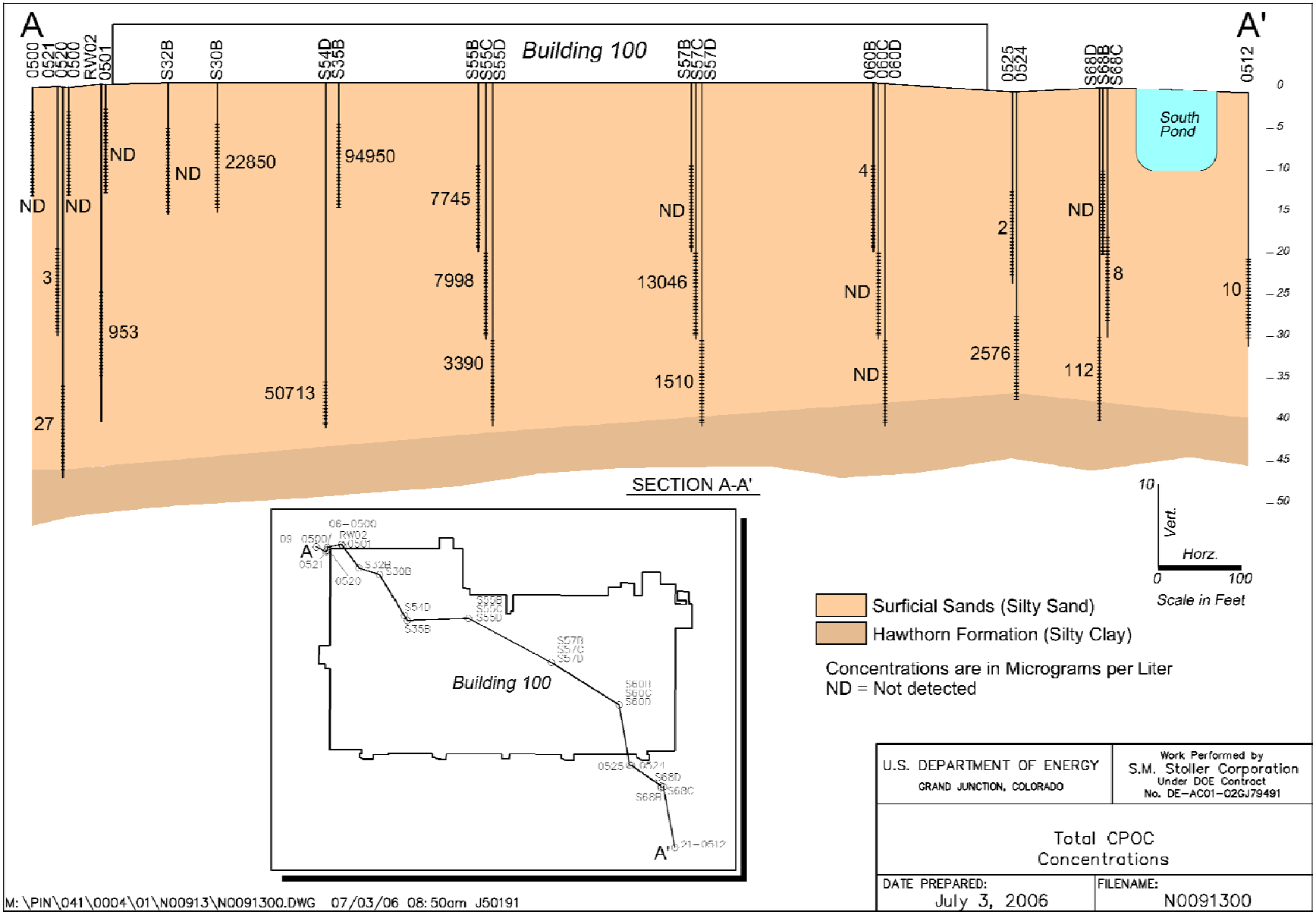

Figure 17. Cross Section Showing Total COPC Concentrations with Depth

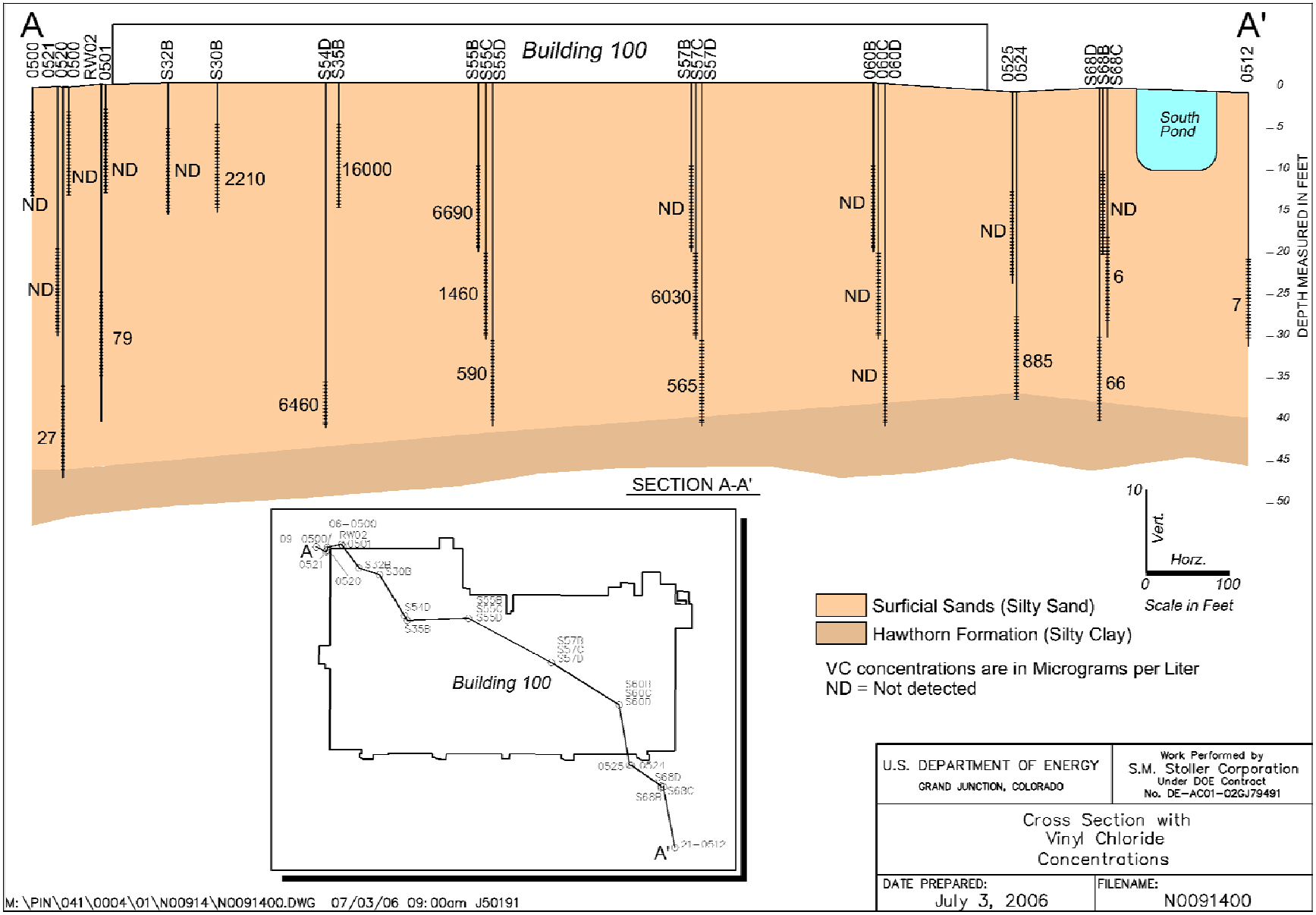

Figure 18. Cross Section Showing VC Concentrations with Depth

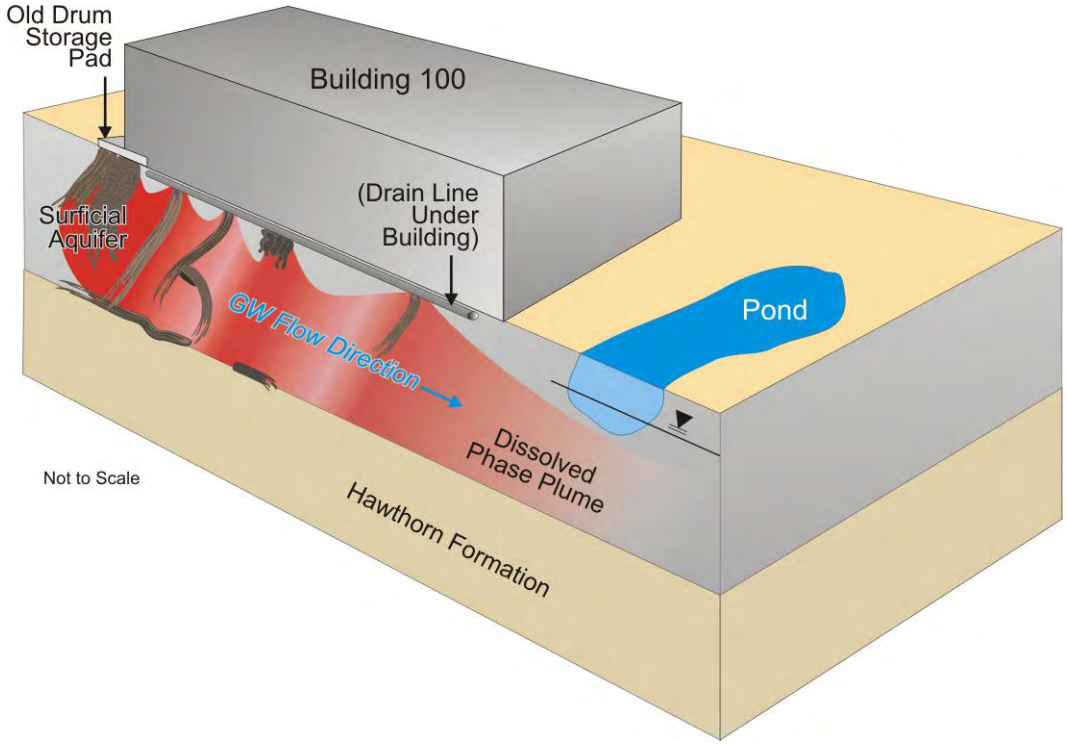

Figure 19. Building 100 Area Conceptual Model

End of current text

Table 4. Building 100 Area Well Information

ID	Type	Completion Zone	Screen Interval (ft below surface)	Installation Date
PIN06–0500	Monitoring Well	Upper Surficial Aquifer	3–13	4/23/1989
PIN06–0501	Monitoring Well	Upper Surficial Aquifer	3–13	4/23/1989
PIN09–0500	Monitoring Well	Upper Surficial Aquifer	3–13	4/23/1990
PIN10–0500	Monitoring Well	Upper Surficial Aquifer	3–13	4/27/1990
PIN12–0508	Monitoring Well	Upper Surficial Aquifer	3–13	4/24/1990
PIN12–0509	Monitoring Well	Upper Surficial Aquifer	3–13	4/25/1990
PIN12–0510	Monitoring Well	Upper Surficial Aquifer	3–13	4/23/1990
PIN12–0511	Monitoring Well	Upper Surficial Aquifer	3–13	4/23/1990
PIN12–0512	Monitoring Well	Upper Surficial Aquifer	3–13	4/26/1990
PIN12–0513	Monitoring Well	Surficial	15–25	5/9/1995
PIN12–0514	Monitoring Well	Deep Surficial Aquifer	30–40	5/9/1995
PIN12–0515	Monitoring Well	Surficial	15–25	5/10/1995
PIN12–0516	Monitoring Well	Deep Surficial Aquifer	30–40	5/10/1995
PIN12–0517	Monitoring Well	Surficial	15–25	5/11/1995
PIN12–0518	Monitoring Well	Deep Surficial Aquifer	30–40	5/11/1995
PIN12–0520	Monitoring Well	Deep Surficial Aquifer	36–46	5/2/1995
PIN12–0521	Monitoring Well	Surficial	19.5–29.5	5/5/1995
PIN12–0522	Monitoring Well	Deep Surficial Aquifer	32–42	5/3/1995
PIN12–0523	Monitoring Well	Surficial	18–28	5/5/1995
PIN12–0524	Monitoring Well	Deep Surficial Aquifer	27–37	5/12/1995
PIN12–0525	Monitoring Well	Surficial	12–22	5/12/1995
PIN12–0526	Monitoring Well	Surficial	19.5–29.5	10/14/1998
PIN12–0527	Monitoring Well	Floridan	118–137.9	8/25/1999
PIN12–0528	Monitoring Well	Floridan	127–146.9	5/1/2000
PIN12–RW01	Recovery Well	Surficial	19–29	7/6/1995
PIN12–RW02	Recovery Well	Deep Surficial Aquifer	25–35	7/7/1995
PIN12–S29C	Monitoring Well	Surficial	14–24	5/1/1995
PIN12–S30B	Monitoring Well	Upper Surficial Aquifer	5–15	5/1/1995
PIN12–S31B	Monitoring Well	Upper Surficial Aquifer	5–15	5/1/1995
PIN12–S32B	Monitoring Well	Upper Surficial Aquifer	5.5–15.5	5/1/1995
PIN12–S33C	Monitoring Well	Surficial	11–21	7/1/1995
PIN12–S35B	Monitoring Well	Upper Surficial Aquifer	5–15	7/1/1995
PIN12–S36B	Monitoring Well	Upper Surficial Aquifer	5–15	7/1/1995
PIN12–S37B	Monitoring Well	Upper Surficial Aquifer	5–15	7/1/1995
PIN12–S54D	Well Point	Deep Surficial Aquifer	36–41	1/14/1997
PIN12–S55B	Well Point	Upper Surficial Aquifer	10–19.8	1/15/1997
PIN12–S55C	Well Point	Surficial	20.5–30.3	1/15/1997
PIN12–S55D	Well Point	Deep Surficial Aquifer	31–40.8	1/15/1997
PIN12–S56B	Well Point	Upper Surficial Aquifer	10–19.8	1/15/1997
PIN12–S56C	Well Point	Surficial	20.5–30.3	1/15/1997
PIN12–S56D	Well Point	Deep Surficial Aquifer	31–40.8	1/16/1997
PIN12–S57B	Well Point	Upper Surficial Aquifer	10–19.8	1/17/1997
PIN12–S57C	Well Point	Surficial	20.5–30.3	1/17/1997
PIN12–S57D	Well Point	Deep Surficial Aquifer	31.5–41.3	1/17/1997

Table 4 (continued). Building 100 Area Well Information

ID	Type	Completion Zone	Screen Interval (ft below surface)	Installation Date
PIN12–S59B	Well Point	Upper Surficial Aquifer	10–19.8	1/16/1997
PIN12–S59C	Well Point	Surficial	20.5–30.3	1/16/1997
PIN12–S59D	Well Point	Deep Surficial Aquifer	31–40.8	1/16/1997
PIN12–S60B	Well Point	Upper Surficial Aquifer	10–19.8	1/17/1997
PIN12–S60C	Well Point	Surficial	20.5–30.3	1/17/1997
PIN12–S60D	Well Point	Deep Surficial Aquifer	31–40.8	1/17/1997
PIN12–S67B	Monitoring Well	Upper Surficial Aquifer	10–19.83	9/6/2001
PIN12–S67C	Monitoring Well	Surficial	20–29.83	9/6/2001
PIN12–S67D	Monitoring Well	Deep Surficial Aquifer	30–39.83	9/6/2001
PIN12–S68B	Monitoring Well	Upper Surficial Aquifer	10–20	3/19/2002
PIN12–S68C	Monitoring Well	Surficial	18–28	3/19/2002
PIN12–S68D	Monitoring Well	Deep Surficial Aquifer	30–40	3/19/2002
PIN12–S69B	Monitoring Well	Upper Surficial Aquifer	10–20	3/20/2002
PIN12–S69C	Monitoring Well	Surficial	20–30	3/20/2002
PIN12–S69D	Monitoring Well	Deep Surficial Aquifer	30–40	3/20/2002
PIN12–S70B	Monitoring Well	Upper Surficial Aquifer	10–20	3/19/2002
PIN12–S70C	Monitoring Well	Surficial	20–30	3/19/2002
PIN12–S70D	Monitoring Well	Deep Surficial Aquifer	30–40	3/19/2002
PIN12–S71B	Monitoring Well	Upper Surficial Aquifer	10–20	3/19/2002
PIN12–S71C	Monitoring Well	Surficial	20–30	3/19/2002
PIN12–S71D	Monitoring Well	Deep Surficial Aquifer	30–40	3/19/2002
PIN12–S72B	Monitoring Well	Upper Surficial Aquifer	10–20	3/19/2002
PIN12–S72C	Monitoring Well	Surficial	20–30	3/19/2002
PIN12–S72D	Monitoring Well	Deep Surficial Aquifer	30–40	3/19/2002
PIN12–S73B	Monitoring Well	Upper Surficial Aquifer	10–20	3/20/2002
PIN12–S73C	Monitoring Well	Surficial	20–30	3/20/2002
PIN12–S73D	Monitoring Well	Deep Surficial Aquifer	30–40	3/20/2002
PIN12–TE03	Monitoring Well	Upper Surficial Aquifer	unknown	11/1/1985
PIN21–0500	Monitoring Well	Upper Surficial Aquifer	7–17	8/14/1991
PIN21–0501	Monitoring Well	Surficial	20–28	8/14/1991
PIN21–0502	Monitoring Well	Upper Surficial Aquifer	7–17	8/12/1991
PIN21–0503	Monitoring Well	Surficial	20–28	8/13/1991
PIN21–0504	Monitoring Well	Upper Surficial Aquifer	7–17	8/13/1991
PIN21–0505	Monitoring Well	Surficial	20–28	8/13/1991
PIN21–0512	Monitoring Well	Surficial	20–29.5	10/13/1998

Table 7. COPC Concentrations at the Building 100 Area in March 2006 (reported in micrograms per liter)[a]

Location	Screen Depth (ft)	Date Sampled	TCE	*cis*-1,2-DCE	*trans*-1,2-DCE	Total 1,2-DCE[a]	1,1-DCE	Vinyl Chloride	Total COPC[b]
FDEP MCL			**3**	**70**	**100**	**63**	**7**	**1**	
PIN06									
0500	3–13	4/12/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/15/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
0501	3–13	4/12/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/15/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
PIN09									
0500	3–13	4/12/2005	<0.5	0.52J	<0.5	0.52J	<0.5	<0.5	ND
		3/14/2006	<0.5	0.51J	<0.5	0.51J	<0.5	<0.5	ND
PIN10									
0500	3–13	4/12/2005	<0.5	1.8	<0.5	1.8	<0.5	<0.5	1.8
		3/14/2006	<0.5	0.56J	<0.5	0.56J	<0.5	<0.5	ND
PIN12									
0508	3–13	4/12/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/15/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
0509	3–13	4/12/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/15/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
0510	3–13	4/12/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/15/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
0511	3–13	4/9/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/11/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
0512	3–13	4/9/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/11/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
0513	15–25	4/12/2005	<0.5	2.4	1.3	3.7	<0.5	6.1	9.8
		3/11/2006	<0.5	0.58J	1.1	1.1	<0.5	1.9	3
0514	30–40	4/12/2005	<0.5	5.1	21.8	26.9	<0.5	24.5	51.4
		10/6/2005	<0.5	9.4	28.4	37.8	<0.5	35.6	73.4
		3/13/2006	<0.5	4.5	21.7	26.2	<0.5	32.9	59.1
0515	15–25	4/9/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/11/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
0516	30–40	4/9/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/11/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
0517	15–25	4/9/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/11/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
0518	30–40	4/9/2005	<0.5	<0.5	<0.5	ND	<0.5	1.4	1.4
		3/11/2006	<0.5	<0.5	<0.5	ND	<0.5	1.3	1.3
0520	36–46	4/12/2005	<0.5	<0.5	<0.5	ND	<0.5	19.5	19.5
		3/15/2006	<0.5	<0.5	<0.5	ND	<0.5	27.3	27.3
0521	19.5–29.5	4/12/2005	1.5	1.6	<0.5	1.6	<0.5	<0.5	3.1
		3/15/2006	1.5	1.9	<0.5	1.9	<0.5	0.91J	3.4
0522	32–42	4/12/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/15/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
0523	18–28	4/12/2005	<0.5	0.66J	<0.5	0.66J	<0.5	0.57J	ND

Table 7 (continued). COPC Concentrations at the Building 100 Area in March 2006 (reported in micrograms per liter)[a]

Location	Screen Depth (ft)	Date Sampled	TCE	*cis*-1,2-DCE	*trans*-1,2-DCE	Total 1,2-DCE[a]	1,1-DCE	Vinyl Chloride	Total COPC[b]
FDEP MCL			**3**	**70**	**100**	**63**	**7**	**1**	
		3/15/2006	<0.5	0.72J	<0.5	0.72J	<0.5	<0.5	ND
0524	27–37	4/11/2005	356	3,390	<50	3,390	182	1,440	5,368
		10/10/2005	123	1,670	19.8	1,689.8	80.6	713	2,606
		3/10/2006	98.6	1,530	<25	1,530	62.7	885	2,576
0525	12–22	4/9/2005	<0.5	2	<0.5	2	<0.5	<0.5	2
		3/11/2006	<0.5	1.9	<0.5	1.9	<0.5	<0.5	1.9
0526	19.5–29.5	4/11/2005	<0.5	1.5	0.58J	1.5	<0.5	1.1	2.6
		10/10/2005	<0.5	3.4	1.4	4.8	<0.5	0.69J	4.8
		3/9/2006	<0.5	1.4	0.61J	1.4	<0.5	<0.5	1.4
0527	118–137.9	4/14/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/15/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
0528	127–146.9	4/9/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/11/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
RW01	19–29	4/5/2005	4,390	2,770	<50	2,770	<50	996	8,156
		7/6/2005	4,220	2,440	<50	2,440	<50	641	7,301
		10/4/2005	4,390	2,700	51.9J	2,700	<50	783	7,873
		3/2/2006	4,140	2,550	54.2J	2,550	<50	716	7,406
RW02	25–35	4/5/2005	298	556	42.6	598.6	13.6	89.4	999.6
		7/6/2005	264	470	34.9	504.9	12.7	55.6	837.2
		10/4/2005	398	562	51.3	613.3	22.1	88.5	1,122
		3/2/2006	271	551	37.4	588.4	15	79	953.4
S29C	14–24	4/6/2005	<0.5	<0.5	3.3	3.3	<0.5	<0.5	3.3
		3/8/2006	<0.5	<0.5	3	3	<0.5	11.6	14.6
S31B	5–15	4/6/2005	<0.5	0.95J	<0.5	0.95J	<0.5	<0.5	ND
		3/8/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
S32B	5.5–15.5	4/6/2005	<0.5	1.6	<0.5	1.6	<0.5	<0.5	1.6
		3/8/2006	<0.5	0.92J	<0.5	0.92J	<0.5	<0.5	ND
S33C	11–21	4/6/2005	<5	74.1	18	92.1	<5	385	477.1
		3/8/2006	1.9	72.6	14.6	87.2	1	318	408.1
S35B	5–15	4/8/2005	23,800	67,600	8,210	75,810	211	15,000	114,821
		10/7/2005	11,600	33,700	5,010	38,710	146E	7,500	57,956
		3/9/2006	16,600	53,200	9,150	62,350	139J	16,000	94,950
S36B	5–15	4/6/2005	<0.5	1.1	<0.5	1.1	<0.5	2.2	3.3
		3/8/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
S37B	5–15	4/6/2005	<0.5	58.9	1.1	60	<0.5	80.8	140.8
		3/8/2006	<0.5	44.8	0.87J	44.8	<0.5	59.2	104
S67B	10–19.83	4/12/2005	<5	25.1	<5	25.1	<5	572	597.1
		3/16/2006	<0.5	25.5	5.1	30.6	<0.5	406	436.6

Table 7 (continued). COPC Concentrations at the Building 100 Area in March 2006 (reported in micrograms per liter)[a]

Location	Screen Depth (ft)	Date Sampled	TCE	*cis*-1,2-DCE	*trans*-1,2-DCE	Total 1,2-DCE[a]	1,1-DCE	Vinyl Chloride	Total COPC[b]
FDEP MCL			**3**	**70**	**100**	**63**	**7**	**1**	
S67C	20–29.83	4/12/2005	<10	616	88.2	704.2	<10	304	1,008
		3/16/2006	<0.5	267	49.5	316.5	4.1	210	530.6
S67D	30–39.83	4/11/2005	<1	147	16	163	1.6J	126	289
		3/16/2006	<1	87.9	13.5	101.4	1.4J	77.1	178.5
S68B	10–20	4/11/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/11/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
S68C	18–28	4/11/2005	<0.5	3.6	<0.5	3.6	<0.5	4.6	8.2
		3/11/2006	<0.5	2.2	<0.5	2.2	<0.5	5.9	8.1
S68D	30–40	4/11/2005	<0.5	56.7	0.87J	56.7	<0.5	45.6	102.3
		3/11/2006	<0.5	45.7	0.72J	45.7	<0.5	66.2	111.9
S69B	10–20	4/12/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/14/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
S69C	20–30	4/12/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/14/2006	<0.5	<0.5	<0.5	ND	<0.5	1	1
S69D	30–40	4/12/2005	<0.5	0.53J	<0.5	0.53J	<0.5	<0.5	ND
		3/14/2006	<0.5	1	<0.5	1	<0.5	0.5J	1
S70B	10–20	4/12/2005	<0.5	18.5	<0.5	18.5	<0.5	<0.5	18.5
		3/14/2006	<0.5	18.8	<0.5	18.8	<0.5	23.4	42.2
S70C	20–30	4/12/2005	<0.5	18.1	4.7	22.8	0.59J	<0.5	22.8
		3/14/2006	<0.5	26.1	8.8	34.9	0.95J	26	60.9
S70D	30–40	4/12/2005	<0.5	11.3	4.1	15.4	0.51J	<0.5	15.4
		3/14/2006	<0.5	14.9	5.6	20.5	<0.5	11.3	31.8
S71B	10–20	4/13/2005	<0.5	0.58J	<0.5	0.58J	<0.5	<0.5	ND
		3/14/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
S71C	20–30	4/13/2005	<0.5	53.2	26.8	80	1.2	59.3	140.5
		3/14/2006	<0.5	32.5	19.8	52.3	0.73J	41.5	93.8
S71D	30–40	4/13/2005	<0.5	5.2	1.6	6.8	<0.5	2.7	9.5
		3/14/2006	<0.5	5.2	2.3	7.5	<0.5	6.3	13.8
S72B	10–20	4/13/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/13/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
S72C	20–30	4/13/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/13/2006	<0.5	1.2	<0.5	1.2	0.57J	1.1	2.3
S72D	30–40	4/13/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/13/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
S73B	10–20	4/13/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/14/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
S73C	20–30	4/13/2005	<0.5	2	5.1	7.1	<0.5	13	20.1
		10/7/2005	<0.5	1	3.6	4.6	<0.5	8.9	13.5
		3/10/2006	<0.5	<0.5	2.3	2.3	<0.5	9.3	11.6
S73D	30–40	4/13/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/14/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND

Table 7 (continued). COPC Concentrations at the Building 100 Area in March 2006 (reported in micrograms per liter)[a]

Location	Screen Depth (ft)	Date Sampled	TCE	*cis*-1,2-DCE	*trans*-1,2-DCE	Total 1,2-DCE[a]	1,1-DCE	Vinyl Chloride	Total COPC[b]
FDEP MCL			**3**	**70**	**100**	**63**	**7**	**1**	
TE03	–	4/9/2005	<0.5	<0.5	<0.5	ND	<0.5	4.2	4.2
		3/11/2006	<0.5	<0.5	<0.5	ND	<0.5	4.2	4.2
PIN21									
0500	7–17	4/13/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/13/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
0501	20–28	4/13/2005	<0.5	1.5	<0.5	1.5	<0.5	<0.5	1.5
		3/13/2006	<0.5	1.4	<0.5	1.4	<0.5	<0.5	1.4
0502	7–17	4/12/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/15/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
0503	20–28	4/12/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/15/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
0504	7–17	4/11/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/11/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
0505	20–28	4/11/2005	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
		3/11/2006	<0.5	<0.5	<0.5	ND	<0.5	<0.5	ND
0512	20–29.5	4/12/2005	<0.5	1.7	<0.5	1.7	<0.5	<0.5	1.7
		3/11/2006	<0.5	2.4	<0.5	2.4	<0.5	7.1	9.5

[a]Total 1,2-DCE is the sum of *cis*-1,2-DCE and *trans*-1,2-DCE.
[b]Total COPC is the sum of the individual COPC concentrations. The *cis*-1,2-DCE and *trans*-1,2-DCE values are not part of the total COPC value because these values are included in the total 1,2-DCE value. "J" values are not included in the total COPC value.

ND = Not detected.
J = Estimated value, result is between the reporting limit and the method detection limit.
Arsenic, while a COPC, is not included in this table, nor in the Total COPC value.

Table 11. All Historical Dehalococcoides Ethenogenes *and Dissolved Gas Data from Building 100 Area Wells*

Well	Date	DHC[a] (copy number/L)	Hydrogen (nM)	Ethane (µg/L)	Ethene (µg/L)	Methane (µg/L)	Carbon dioxide (mg/L)
12-0513	2/2002	--	--	0.73	3.3	170	20
12-0514	2/2002	--	--	ND	ND	220	32
	1/2003	Moderate	--	--	--	--	--
	3/2003	Moderate	--	ND	0.36	450	98
	4/2003	--	--	0.44	ND	360	79
	6/2003	--	--	ND	ND	410	170
	8/2003	--	--	1	8.1	1,800	270
	9/2003	Moderate	--	ND	15	11,000	230
	11/2003	--	--	1.2	8.2	5,700	66
	1/2004	--	--	1.2	6.4	3,600	80
	3/2004	--	--	ND	4.7	1,900	110
	5/2004	Moderate	--	ND	ND	4,400	560
	10/2005	Absent	1.5	0.2	2	9,600	120
	3/2006	9,000,000	1.8	0.11	0.54	3,500	140
12-0523	10/2004	--	1.1	0.019	0.0058	54	46
	4/2005	--	0.67	0.011	0.015	88	52
12-0524	2/2002	--	--	ND	ND	680	40
	10/2004	--	1	0.45	28	4,300	160
	4/2005	--	1	0.38	21	4,200	110
	10/2005	14,300,000	0.75	0.33	19	4,200	120
	3/2006	2,000,000	1.4	0.19	13	1,200	160
12-0525	2/2002	--	--	ND	2	44	23
12-0526	2/2002	--	--	ND	ND	190	43
	1/2003	Moderate	--	--	--	--	--
	3/2003	Absent	--	ND	ND	290	110
	4/2003	--	--	ND	ND	170	97
	6/2003	--	--	ND	ND	390	110
	8/2003	--	--	ND	ND	310	160
	9/2003	Moderate	--	ND	ND	1,100	200
	11/2003	--	--	ND	ND	1,600	66
	1/2004	--	--	ND	ND	7,300	100
	3/2004	--	--	ND	ND	6,800	420
	5/2004	Moderate	--	ND	ND	6,830	850
	10/2004	--	1.6	ND	ND	6,200	290
	4/2005	--	1.4	ND	ND	9,300	240
	10/2005	41,100	180	ND	ND	4,500	280
	3/2006	<1,000	1.4	0.009	0.011	1,700	270
12-S35B	10/2004	--	1.1	120	2,100	3,800	180
	4/2005	--	0.86	130	1,800	4,100	160
	10/2005	1,660,000	0.83	120	1,200	3,100	150
	3/2006	<1,000	1.2	190	1,600	4,000	200

Table 11 (continued). COPC Concentrations at the Building 100 Area in March 2006 (reported in micrograms per liter)[a]

Well	Date	DHC[a] (copy number/L)	Hydrogen (nM)	Ethane (µg/L)	Ethene (µg/L)	Methane (µg/L)	Carbon dioxide (mg/L)
12-S67C	10/2004	--	1.1	6.5	9.2	420	67
	4/2005	--	0.93	5.4	7.5	390	51
12-S73C	1/2003	Absent	--	--	--	--	--
	3/2003	Absent	--	ND	ND	480	100
	4/2003	--	--	0.36	0.46	1,500	100
	6/2003	--	--	ND	ND	510	120
	8/2003	--	--	0.43	0.48	700	150
	9/2003	Moderate	--	ND	ND	1,400	160
	11/2003	--	--	ND	0.38	6,200	93
	1/2004	--	--	ND	ND	4,600	130
	3/2004	--	--	ND	ND	8,700	120
	5/2004	Moderate	--	ND	ND	10,300	747
	10/2005	1,190,000	7.5	0.021	0.48	7,400	220
	3/2006	3,000,000	2.5	0.11	0.43	9,500	280
21-0512	2/2002	--	--	ND	ND	120	22

[a]DHC analyses in 2003 and 2004 were semiquantitative; the options for the results were absent (below detection limit), or low, moderate, or high abundance.
-- = Not Measured.
ND = Not Detected

Table 12. Remediation Technology Evaluation

Technology Type	Description	Meets Criterion 1	Meets Criterion 2	Criterion 3 (Cost)	Conclusions
In Situ Biological Treatment					
Enhanced Biodegradation	Increase the concentration of electron acceptors, electron donors, nutrients, or microorganisms in ground water to enhance the rate of direct or cometabolic, aerobic or anaerobic, biodegradation of organic contaminants.	No	No	High	Fails to meet Criterion 1 due to large plume extent and poor delineation. Fails to meet Criterion 2 (d & e) due to poor delineation and unknown contaminant mass. Cost is high due to large plume and requirement to implement from outside building without interfering with business activities. Additionally, a pilot test of this technology for plume control at the Building 100 Area did not meet MCLs due to potential nutrient limitations and/or incomplete contact with target areas.
Phytoremediation	Process that uses plants to remove, transfer, stabilize, and/or destroy contamination in ground water.	No	No	High	Phytoremediation has potential uses for plume control in contaminated areas adjacent to the building, but is not applicable under the building.
In Situ Physical/Chemical Treatment					
Air Sparging	Air is injected into the subsurface to remove contaminants through volatilization. Typically coupled with soil vapor extraction.	No	No	High	Fails Criterion 1 due to non-implementability. Fails Criterion 2 (a, b, d, e) due to potential health risks from vapor intrusion through the building floor, making the option unacceptable to the STAR Center; also fails due to poor delineation and unknown mass. Cost is high due to large plume and requirement to implement from outside building without interfering with business.
In-Well Air Stripping	Involves pumping of water from a contaminated zone into a well from an upper (or lower) screen zone, sparging the water with air to volatilize contaminants, then pumping the cleaned water back into the subsurface through an upper (or lower) screen zone, thus creating a circulating flow cell.	No	No	High	Fails Criterion 2 (a, b, c, d, e) because would need to be implemented in vertical wells through the floor of the building. Unknown if this technology has been implemented using horizontal wells.
Biosparging	Injection of air into the subsurface to attain aerobic conditions that facilitate direct or cometabolic aerobic biodegradation of contaminants. Sparging is a minor component of this process because air- flow rates are much lower than with air sparging.	No	No	High	Not considered because technology failed at the 4.5 Acre Site, where it was easily implementable.

Table 12 (continued). Remediation Technology Evaluation

Technology Type	Description	Meets Criterion 1	Meets Criterion 2	Criterion 3 (Cost)	Conclusions
Bioslurping	Combines bioventing and vacuum-enhanced free-product recovery to remove light non-aqueous phase liquids from the surface of the water table. Stimulates aerobic bioremediation.	No	No	High	Not applicable. Used to recover Light NAPLs, which are not present at the Building 100 Area.
Dual Phase Extraction (DPE)	Uses a high vacuum system to remove contaminated ground water, non-aqueous phase liquids, and contaminant vapors from the subsurface.	No	No	High	Technology decreased contaminant concentrations at the 4.5 Acre Site, but did not reach MCLs. This technology fails Criterion 2 (c, d, e) due to difficulty inplementing from outside the building, poor delineation, and unknown mass.
Ground Water Pumping	Involves extraction of contaminated ground water from the subsurface to remove contaminant mass and reduce concentrations. Includes ex situ surface treatment.	No	No	High	Fails Criterion 1 due to potential NAPL presence, likely leading to extended operation time. Fails Criterion 2 (c, d, e) due to difficulty of contacting target zones under the building, poor delineation, and unknown mass.
Electrokinetics	Involves mobilizing contaminants by applying an electric potential across the contaminated zone using electrodes placed in the ground. Contaminants then removed via a separate process such as ground water pumping, followed by ex situ treatment of extracted water.	No	No	High	Fails Criterion 1 due to unknown contaminant location and mass. Fails Criterion 2 (c, d, e) due to difficulty of placing electrodes into target zones under the building, poor delineation, and unknown mass.
Permeable Reactive Barrier (PRB) Walls	An opening filled with reactive material is placed to intercept a contaminant plume. Degradation or removal of contaminants occurs as contaminated water passes through the wall. Reactive materials include iron metal, limestone, organic carbon, bone char phosphate, and microorganisms.	No	No	High	A 1999 evaluation of a zero valent iron PRB wall for the Building 100 Area indicated that it could be effective at plume control, but field testing was not conducted. Since that time, long-term studies of PRB walls at several sites across the world have shown previously unknown problems such as clogging with mineral precipitates and hydraulic short-circuiting or by-passing. These problems, combined with non-implementability under the building, exclude this technology from consideration.
Lasagna™	Couples electrically-driven transport (electro-osmosis) with layered treatment zones containing a reactive medium such as zero-valent iron.	No	No	High	Lasagna fails to meet the Criteria for the same reasons as most other technologies: difficulty implementing from outside the building, poor delineation, and unknown contaminant mass.

Table 12 (continued). Remediation Technology Evaluation

Technology Type	Description	Meets Criterion 1	Meets Criterion 2	Criterion 3 (Cost)	Conclusions
In Situ Redox Manipulation	Creates a treatment zone by injection of chemical reagents or microbial nutrients downgradient of the contaminant source. Changes the redox conditions so that contaminants are degraded or immobilized by biotic or abiotic means.	No	No	High	Fails Criterion 1 due to unknown contaminant mass and location. Fails Criterion 2 (c, d, e) because of unknown mass and location. Cost is high due to large plume and requirement to implement from outside building without interfering with business.
Chemical Oxidation. Oxidants include permanganate, Fenton's reagent, and ozone.	Injection of strong oxidizing agents degrades contaminants in place.	No	No	High	A significant problem with any technology that requires subsurface injection of fluids at the STAR Center is contact of the fluids with the entire contaminated area. Ground water models have shown strong evidence of preferential flow pathways that could redirect fluids away from target areas. Technology fails Criteria 1 & 2 and has high cost.
Soil Flushing/ Solubilization 1. Surfactant flushing 2. Cosolvent flushing	Surfactants or cosolvents are applied to the soil or injected into the ground water to enhance NAPL solubility. The ground water containing the solubilized contaminant is then extracted and treated.	No	No	High	This NAPL remediation technology has been shown to have many significant limitations, including difficulty treating heterogeneous soils, reductions in soil porosity and contaminant mobilization, as well as loss of control of mobilized contaminants. Intensive subsurface operations combined with required surface treatment results in high cost.
Dewatering with hot air flushing/vapor extraction	Barrier wall is installed around treatment area, area is dewatered and then flushed with hot air to volatilize and remove contaminants. Vapors require surface treatment.	No	No	High	Not reasonable.
Electrical Heating 1. Six- Phase Heating 2. Three-Phase Heating 3. In Situ Thermal Desorption 4. Radio-Frequency Heating	Electricity is used to resistively or conductively heat the subsurface, volatilizing or destroying contaminants. Vapors removed via vapor extraction system and treated at the surface.	No	No	High	A combination of electrical heating and steam injection has been successful at removing NAPLs at the Northeast Site. However, application of this technology to the Building 100 Area is unreasonable due to health concerns for building occupants, disruption to business activities, and extreme cost.
Contained Recovery of Oily Wastes	Steam and hot water are used to mobilize non-aqueous phase oils for removal via pumping. Typically leaves residual oil in soil matrix.	No	No	High	Not applicable.

Table 12 (continued). Remediation Technology Evaluation

Technology Type	Description	Meets Criterion 1	Meets Criterion 2	Criterion 3 (Cost)	Conclusions
Steam Injection. May include electrical heating of cold spots or use of hydrous pyrolysis to degrade contaminants in situ.	Steam is forced into aquifer through injection wells to vaporize volatile contaminants. Vapors removed through vapor extraction system.	No	No	High	A combination of electrical heating and steam injection has been shown successful at removing NAPLs at the Northeast Site. However, application of this technology to the Building 100 Area is unreasonable due to health concerns for building occupants, disruption to business activities, and extreme cost.
Hydrofracturing and Pneumatic Fracturing	Injection of pressurized water or air creates fractures in low permeability soil. The fractures then serve as conduits to enhance ground water extraction or to enhance injection of chemical amendments.	No	No	High	Fracturing has potential applicability as an enhancement to a primary remediation technology to aid access to low flow areas, but alone would not be effective.
Ex Situ Ground Water Treatment					
Ex Situ Ground Water Technologies. Includes bioreactors, constructed wetlands, adsorption, air stripping, granular activated carbon, ion exchange, precipitation, separation, sprinkler irrigation, and UV oxidation.	This category includes a number of different types of technologies that all require contaminated ground water to be pumped from the subsurface for subsequent surface treatment. Water potentially may be reused after treatment.	No	No	Moderate - High	Ex situ ground water treatment is not considered as a separate remediation technology. Therefore, its evaluation is considered along with any associated in situ treatment technology (e.g., ground water pumping).
Containment					
Ground Water Pumping for containment	Extraction of ground water to contain/control contaminant plume. Considered separately from ground water pumping to remove contaminant mass (as described earlier in this table).	No	No	High	Ground water pumping for containment will not meet remediation objectives (MCLs). Applicable only for plume control. High long-term cost.
Physical Barriers Includes slurry wall, geosynthetic wall, grout, deep soil mixing, surface caps, frozen soil barriers, calcite barriers, biobarriers, and sheet pile.	Physical barriers are defined as subsurface barriers usually made of an impermeable material designed to contain or divert ground water flow, thereby preventing contaminant movement.	No	No	High	Will not meet MCLs. Applicable only for plume control. Would require ground water pumping and ex situ treatment. High long-term cost.
Dual Drainline Techniques	Recovery lines are placed horizontally on top of an impermeable stratigraphic unit and dense non-aqueous phase liquid flows into the collection trenches and seeps into the recovery lines.	No	No	High	Not Applicable

Table 12 (continued). Remediation Technology Evaluation

Technology Type	Description	Meets Criterion 1	Meets Criterion 2	Criterion 3 (Cost)	Conclusions
Removal					
Soil Removal Includes ex situ treatment options.	Excavate contaminated soil and treat on site or send to approved disposal facility.	No	No	High	Would be effective at meeting objectives if implementable. Impossible to implement due to 11-acre occupied building. Extremely high cost.

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Appendix A

Time-Concentration Plots for Selected Building 100 Area Wells

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Figures A-1 through A-4 show time/concentration plots for monitoring wells beneath Building 100 that have recently contained the highest COPC concentrations. The screened intervals of all wells at the Building 100 Area are listed in Table 4.

Well PIN12−S30B is located near the northwest corner of the building; this well may be somewhat influenced by the ground water pumping from recovery well PIN12−RW01. Concentrations of TCE, cDCE, tDCE, and VC have shown considerable variability over time (Figure A−1). However, TCE has recently shown a significant decrease in concentration, from 23,000 µg/L in July 2002 to 545 µg/L in April 2005, the last time the well was sampled.

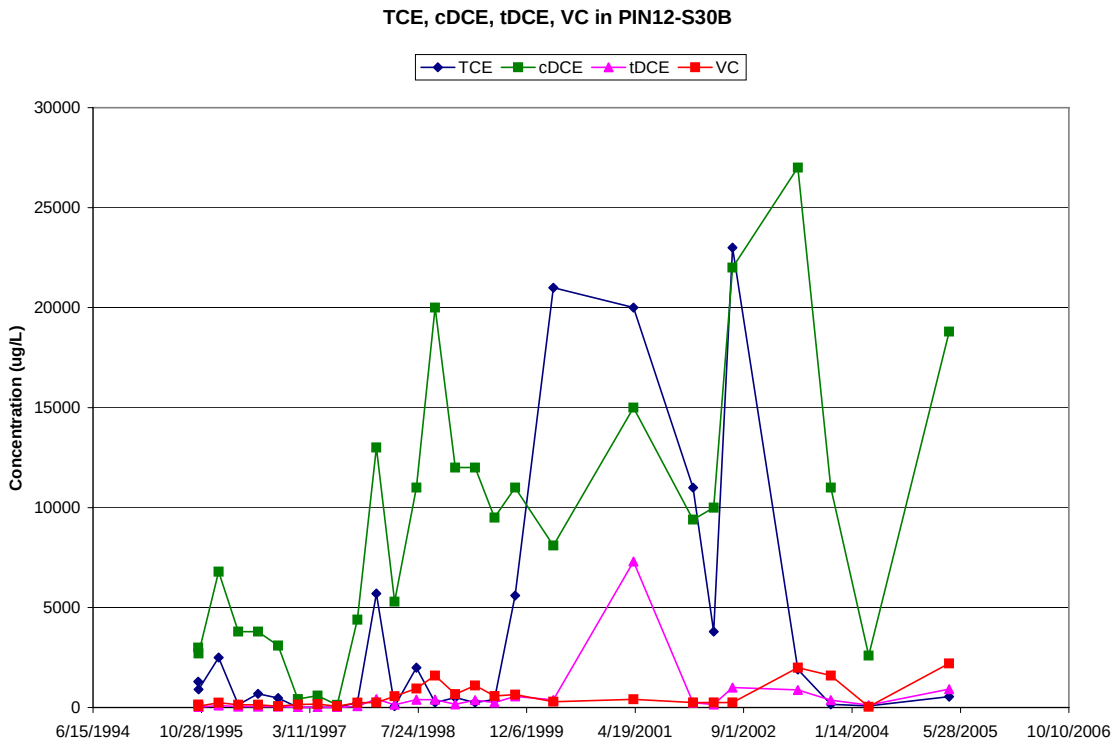

Figure A−1. TCE, cDCE, tDCE, VC in PIN12−S30B

Wells PIN12−S35B and –S54D are centrally located under the western half of the building and are approximately 15 ft apart. Well S35B has contained the highest concentrations of TCE, cDCE, and tDCE of any well at the Building 100 Area. The concentrations of TCE, dDCE, tDCE, and VC in these wells are shown in Figures A−2 and A−3. In well S35B, TCE has shown a relatively steady decrease in concentration since January 1998, while the cDCE concentration has increased for part of that same time but has shown a significant decrease since May 2003. The VC concentration has shown an increase as the TCE and cDCE concentrations have decreased, possibly indicating that biodegradation is responsible for the TCE and DCE decreases. In well S54D, TCE and cDCE concentrations showed general increasing trends until the 2002−2003 time period, but concentrations have decreased since that time, along with a concurrent increase in VC concentration, again potentially indicating that biodegradation processes are occurring.

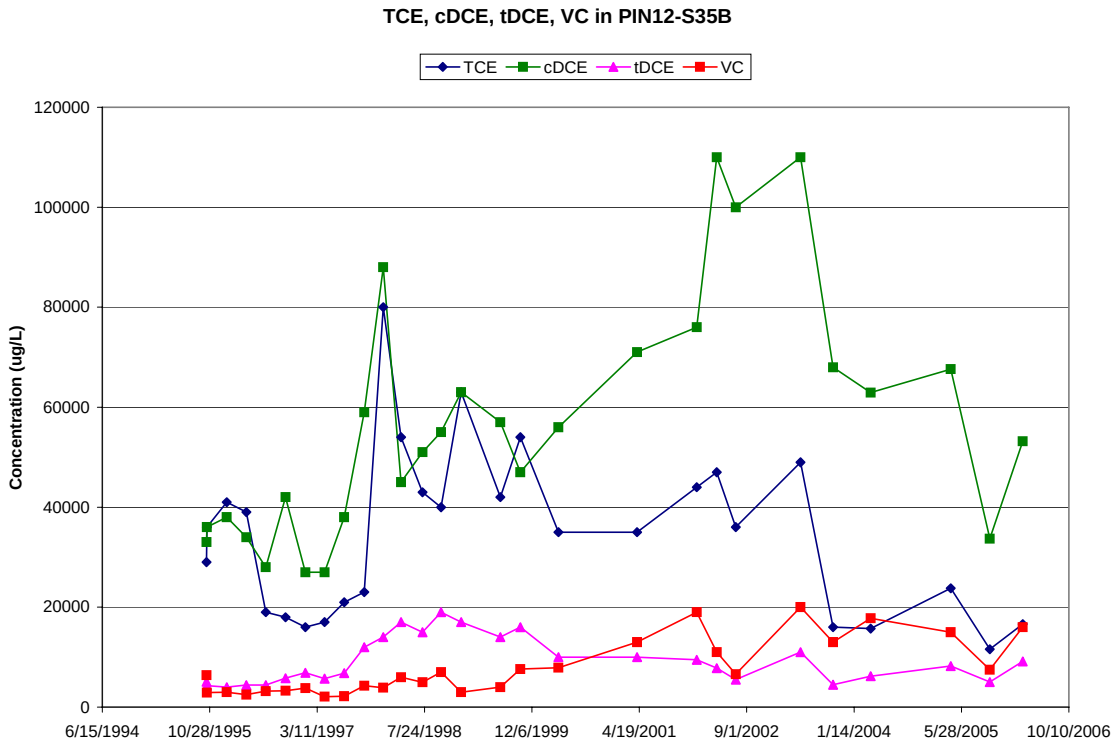

Figure A−2. TCE, cDCE, tDCE, VC in PIN12−S35B

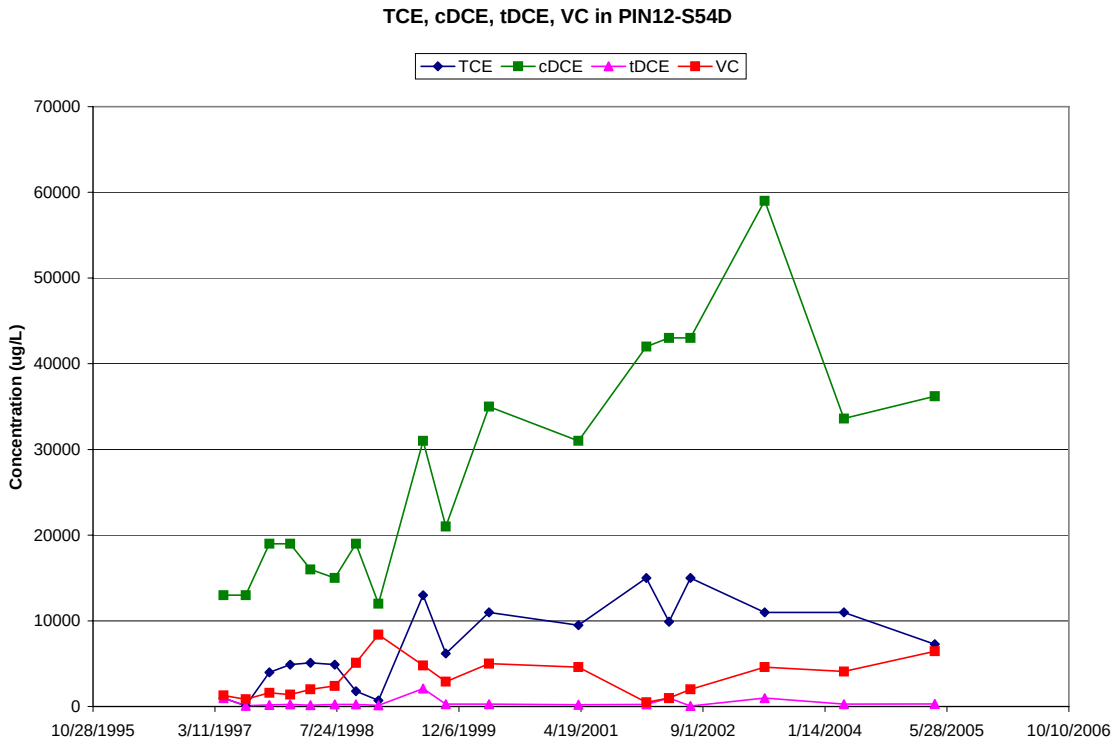

Figure A−3. TCE, cDCE, tDCE, VC in PIN12−S54D

Well PIN12−S57C is located nearly in the center of Building 100. TCE, cDCE, and tDCE concentrations have shown a distinct decreasing trend since 1998 (Figure A−4). The VC concentration increased until January 2002, and has since decreased as well. Biodegradation likely is the cause of these trends.

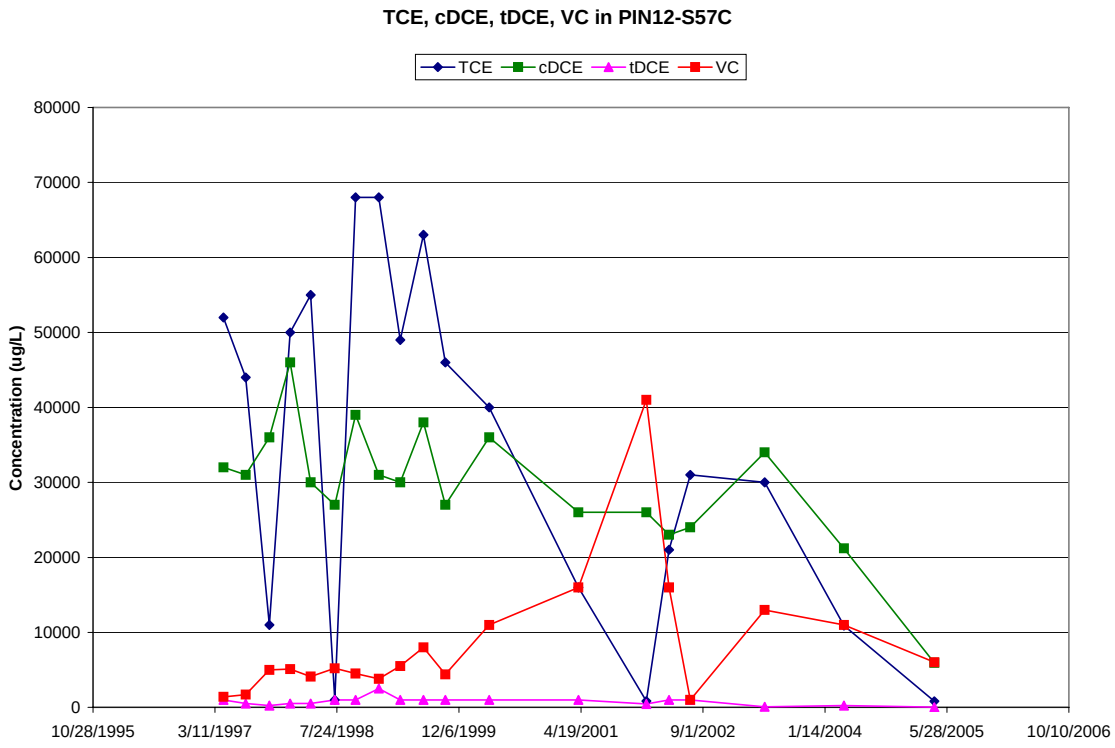

Figure A−4. TCE, cDCE, tDCE, VC in PIN12−S57C

Time-concentration plots for all monitoring wells that contained detected COPCs in March 2006 and are located hydraulically downgradient from the building are shown in Figures A−5 through A−20 in Appendix A. The screened intervals of all wells at the Building 100 Area are listed in Table 4.

Wells PIN12−0513 and 12−0514, located north of the southeast corner of the building, show overall decreasing concentration trends for all detected COPCs (Figures A−5 and A−6). Well PIN12−0524 was involved in the enhanced bioremediation pilot test that ran from March 2003 to May 2004, resulting in the significant concentration decreases during that time. Concentrations did increase slightly at the end of the pilot test, but subsequent monitoring has shown that concentrations continue the overall decreasing trend. Well PIN12−0513 was not directly involved in the pilot test, but COPC concentration decreases during March 2003 to May 2004 likely are an effect of the test. As with well PIN12−0514, subsequent monitoring has shown that concentrations continue the overall decreasing trend.

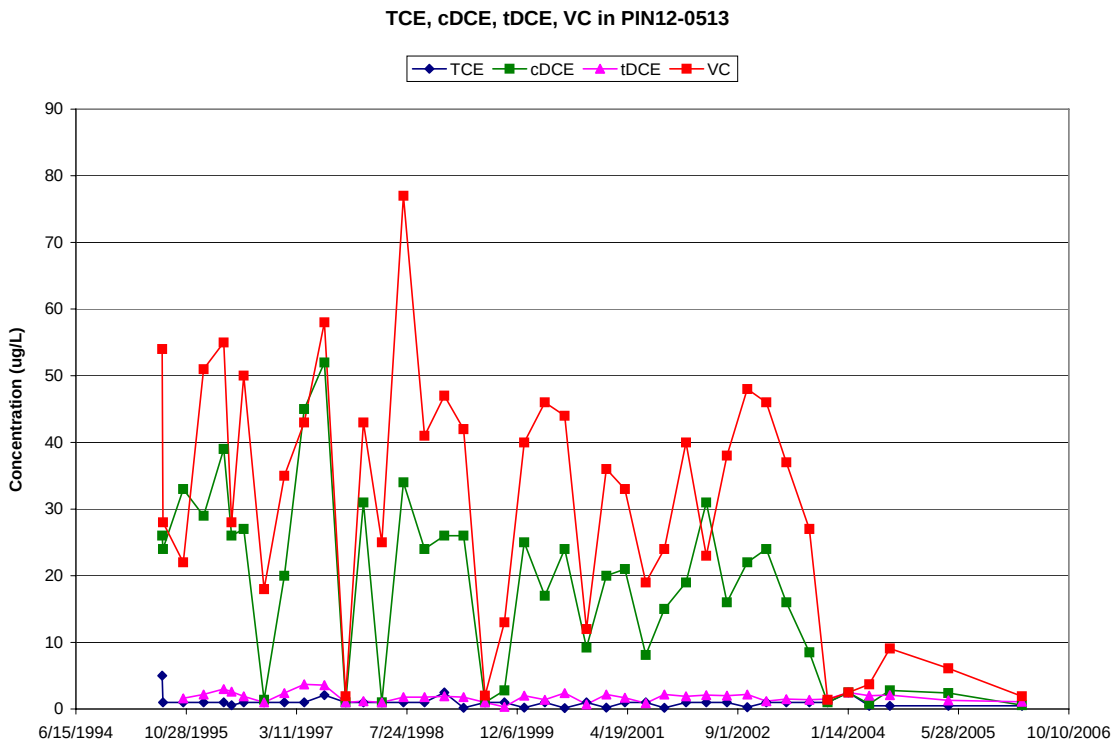

Figure A−5. TCE, cDCE, tDCE, VC in PIN12−0513

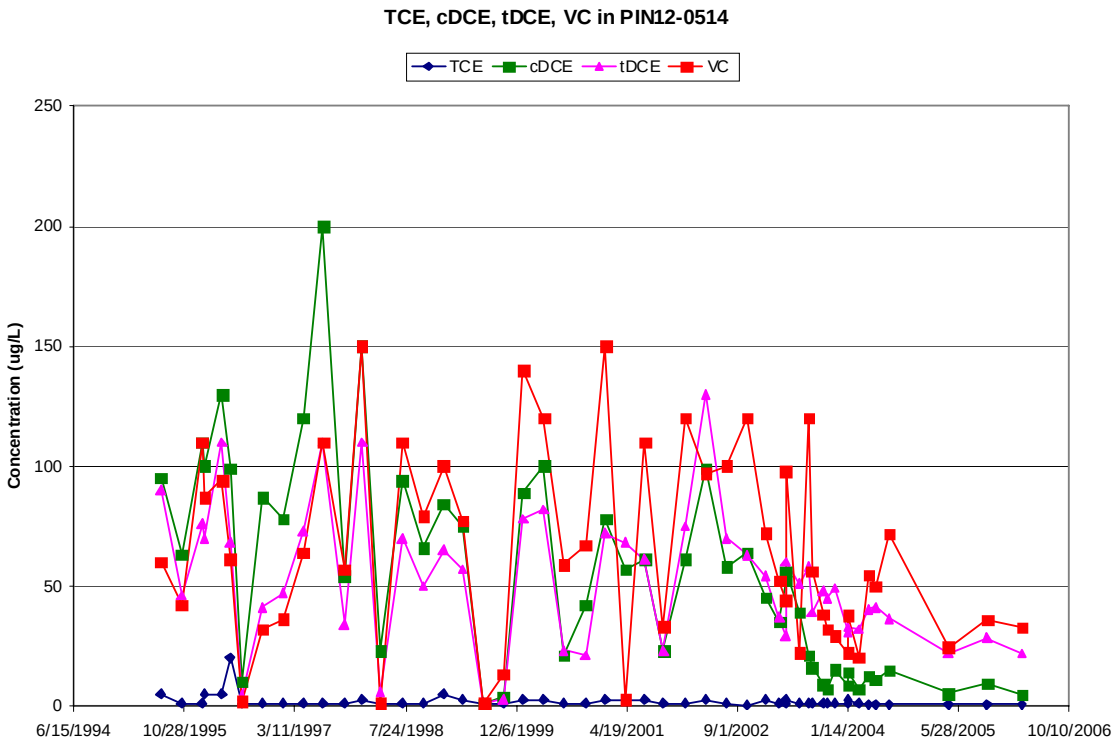

Figure A−6. TCE, cDCE, tDCE, VC in PIN12−0514

Wells PIN12−S71B, −S71C, and –S71D are located east of wells PIN12−0513/0514 and show low to moderate concentrations of cDCE and VC. The “B,” “C,” and “D” designations on these wells and other wells with similar designations indicate screened intervals of 10−20, 20−30, and 30−40 ft bls, respectively (Table 4). The cDCE and VC concentrations in S71B and S71C show decreasing trends over the last 2−3 years; S71D shows very low concentrations but an increasing trend for these two COPCS (Figure A−7 through A−9). The increasing trend could be due to mass transfer from the higher concentrations observed in S71C, or could be due to production of these two compounds, which are daughter products of biodegradation processes.

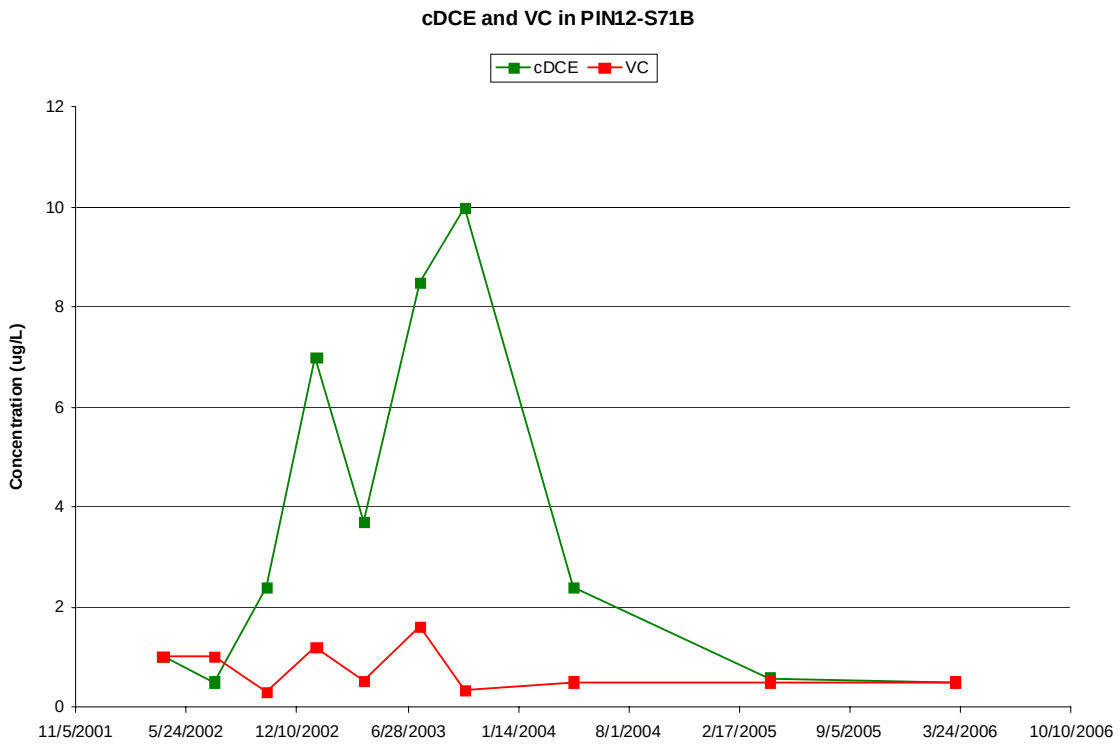

Figure A−7. cDCE and VC in PIN12−S71B

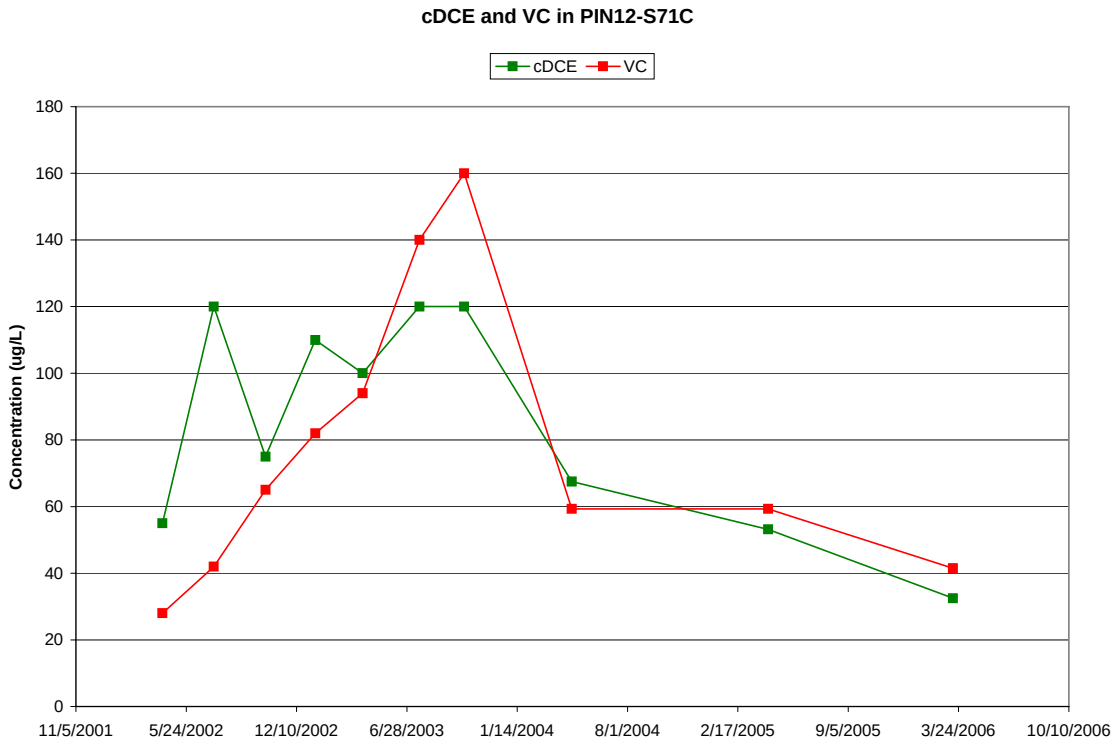

Figure A−8. cDCE and VC in PIN12−S71C

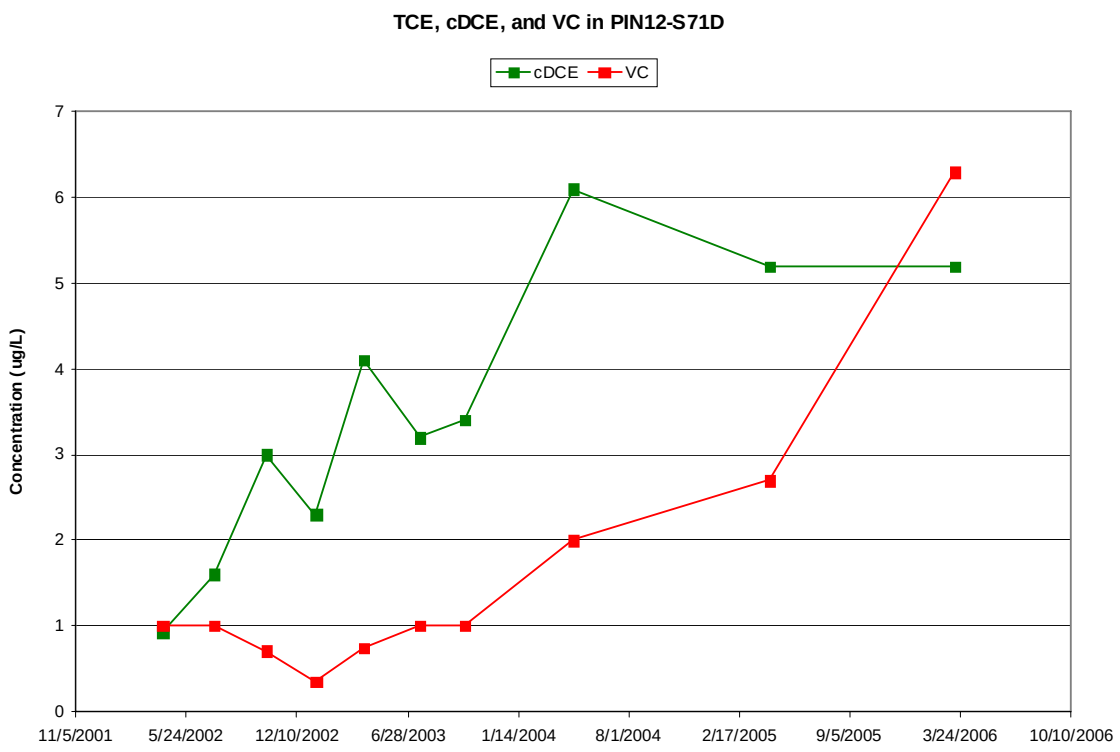

Figure A−9. TCE, cDCE, and VC in PIN12−S71D

Wells PIN12−S70B, −S70C, and –S70D are located directly south of the S71 series wells, and show low concentrations of cDCE and VC (Figures A−10 through A−12). Well S70B shows a constant or slightly decreasing concentration trend for both cDCE and VC. Wells S70C and S70D show constant or slightly increasing trends for both cDCE and VC. The slightly increasing trends likely are due to production of these compounds during biodegradation.

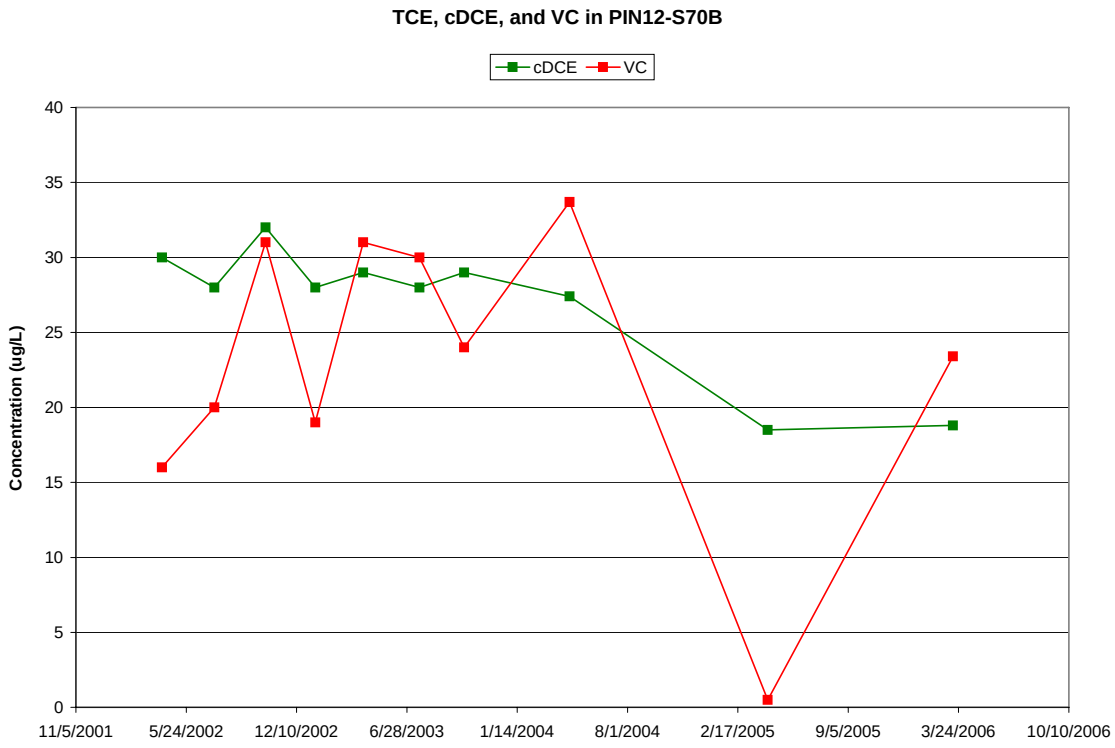

Figure A−10. TCE, cDCE, and VC in PIN12−S70B

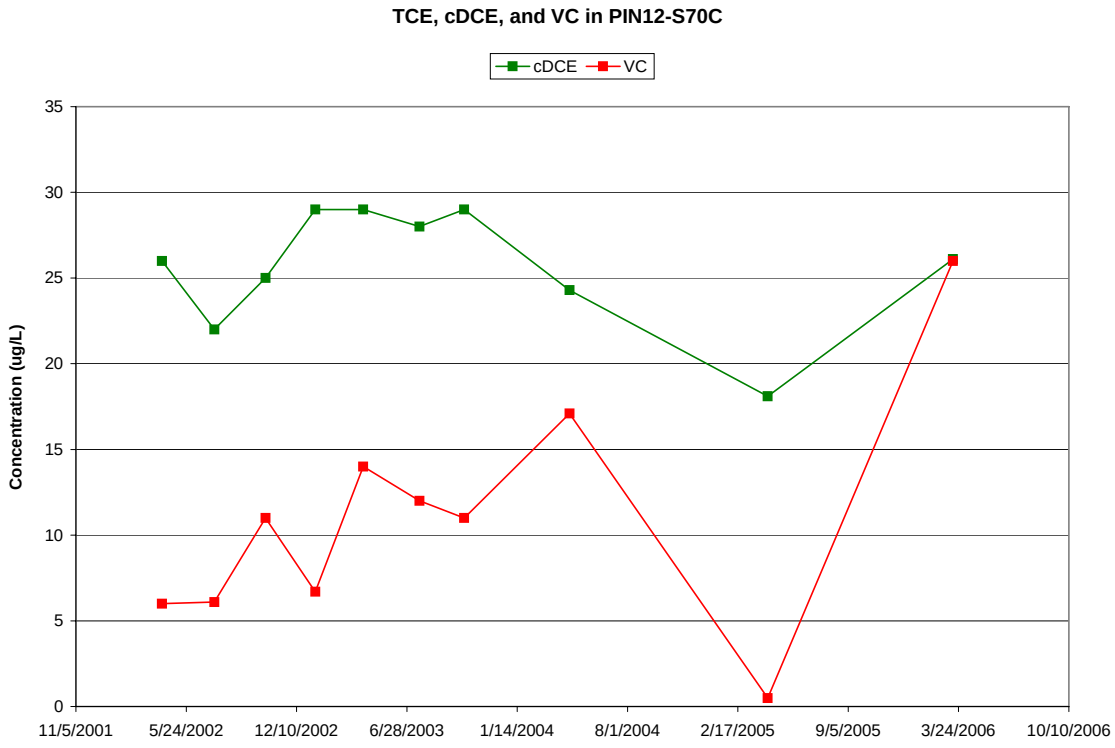

Figure A−11. TCE, cDCE, and VC in PIN12−S70C

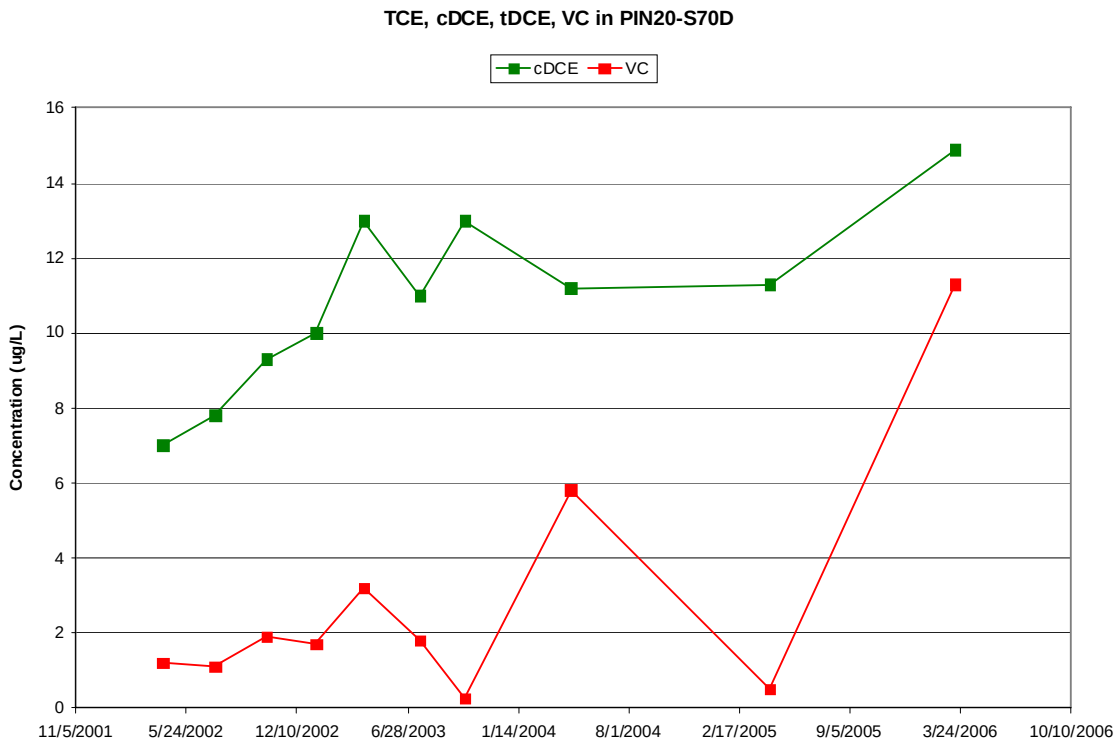

Figure A−12. TCE, cDCE, and VC in PIN12−S70D

Well PIN12−0526, located east of the S70 wells, shows an overall decreasing trend for cDCE and VC (Figure A−13). Data collected in March 2006 show that VC was not detected in this well and that cDCE and tDCE were detected at concentrations <2 µg/L, well below their MCLs.

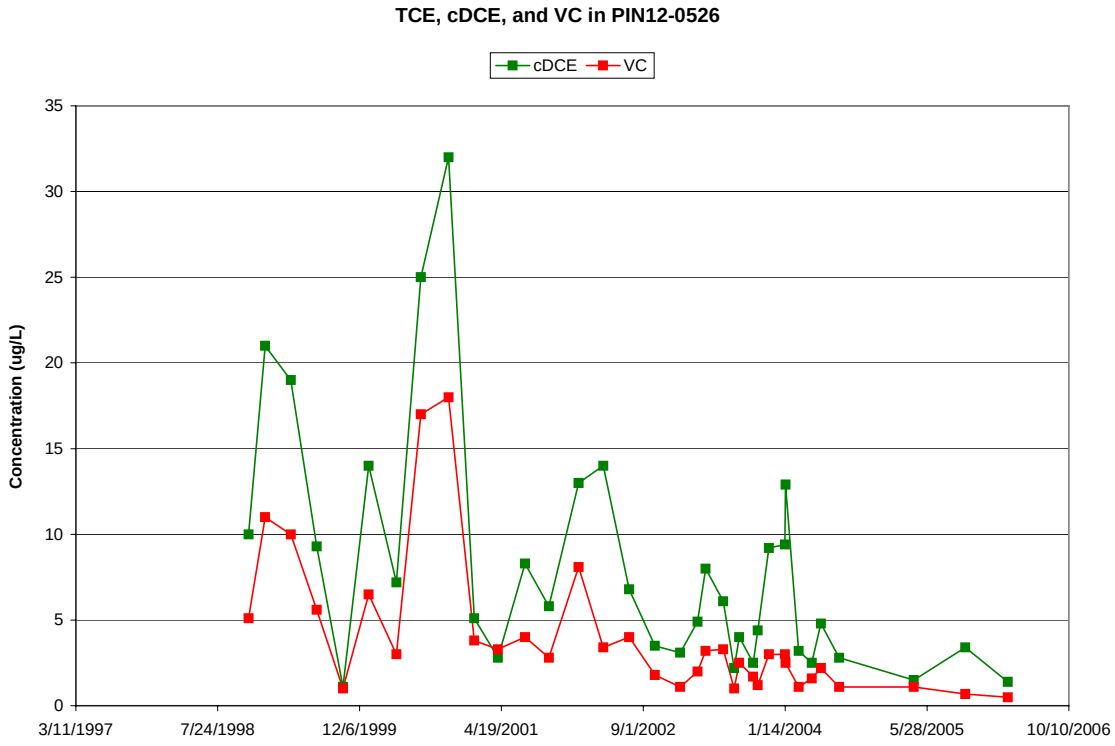

Figure A−13. TCE, cDCE, and VC in PIN12−0526

Wells PIN12−S73B, −S73C, and –S73D are located east of well PIN12−0526 and are approximately 50 ft from the STAR Center property boundary. COPCs have never been detected in well S73B. COPCs have never been detected above the MCL in well S73D, with the only detections being cDCE at <2 µg/L. In well S73C, cDCE, tDCE, and VC show decreasing concentration trends, and only VC has been detected above the MCL (Figure A−14).

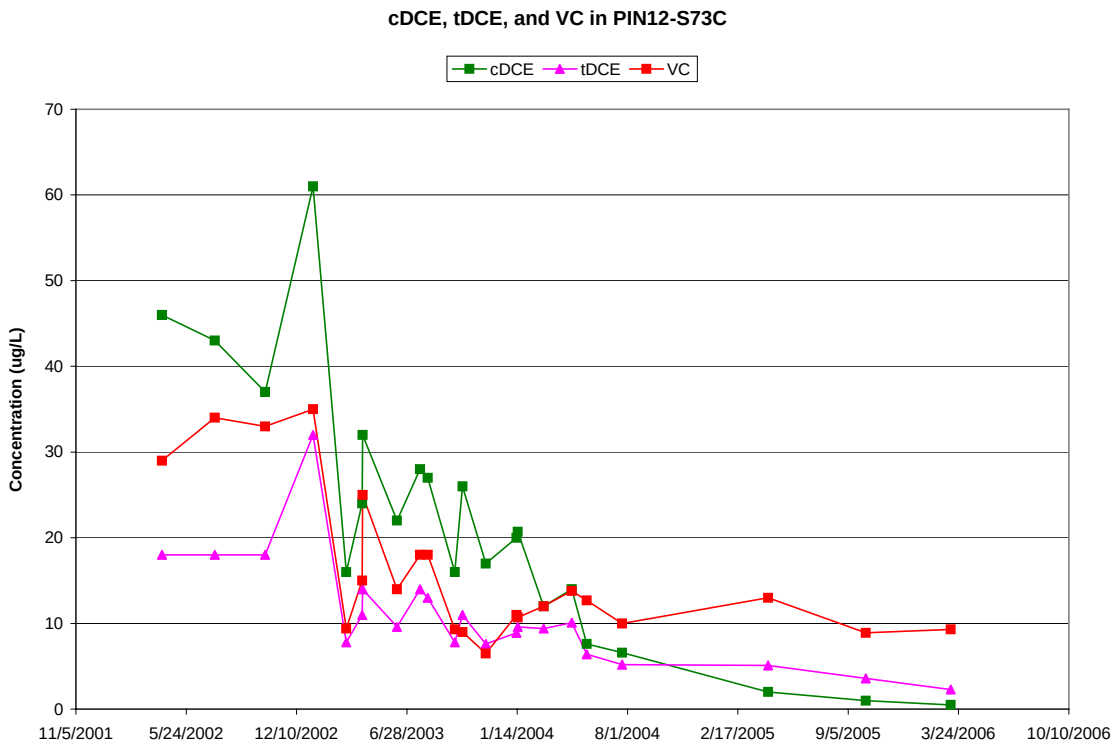

Figure A−14. cDCE, tDCE, and VC in PIN12−S73C

Wells PIN12−S72B, −S72C, and –S73D are located north of the S73 wells. COPCs have never been detected in well S72B. COPCs have never been detected in well S73D, with the exception of cDCE and VC at <2 µg/L in January 2003. Well S72C has contained detections of both cDCE and VC, with the highest concentrations measured in January 2003 (Figure A−15). cDCE was never detected above the MCL, and VC was detected above the MCL only twice, at 5.6 µg/L in January 2003 and 1.1 µg/L in March 2006.

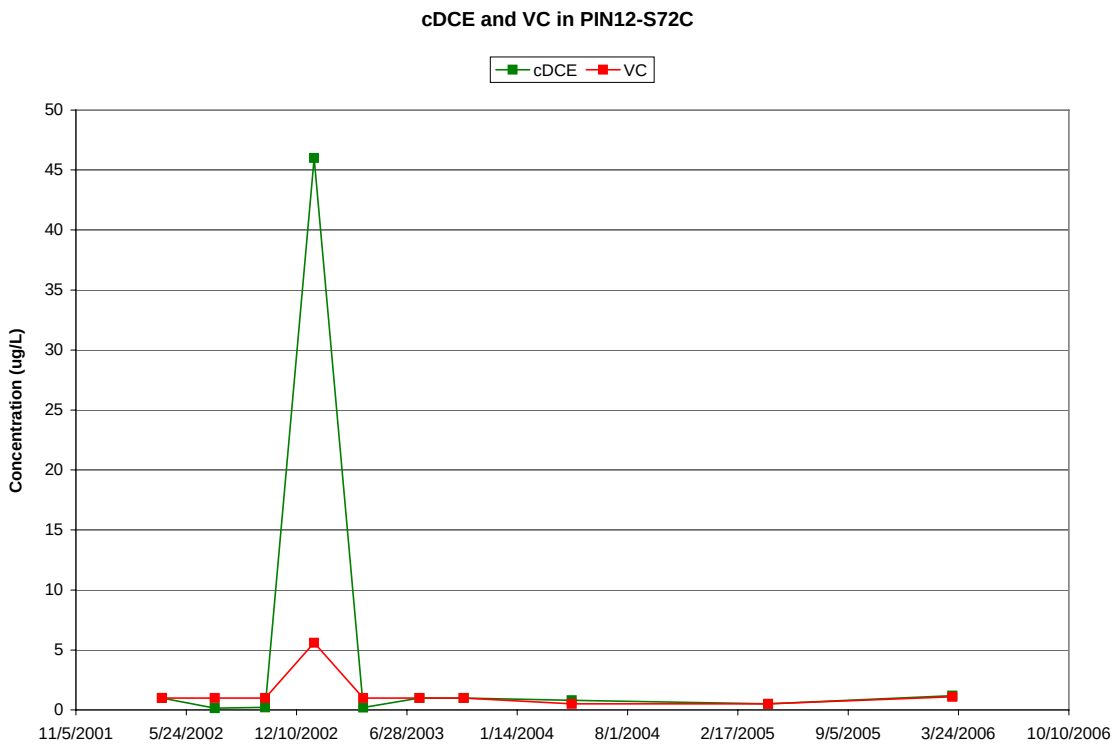

Figure A−15. cDCE and VC in PIN12−S72C

Wells PIN12−0524 and –0525 are located west of the southeast corner of the building. Concentration trends in these two wells suggest that a pulse of TCE, DCE, and VC is moving through the aquifer (Figures A−16 and A−17). Well 0525 is the shallower well of the pair, being screened at 12−22 ft bls, while well 0524 is screened at 27−37 ft bls. As can be seen by comparing the two figures, which have the same date axis, the pulse of contaminants appeared first in the shallow well, indicating that ground water in this area flows at a slightly higher rate in the shallow surficial aquifer than in the deep surficial aquifer. This is consistent with site information described in Section 2.1. This pulse of contaminants in well 0525 passed by the well over a time period of approximately 3 years, going from non-detect levels to a few hundred µg/L and back to non-detect levels. In well 0524, the pulse appears to have a slightly longer duration due possibly to slower ground water velocity, allowing dispersive and diffusive processes to widen and lengthen the pulse. The concentration trends in well 0524 indicate that the pulse is nearly past the well, based on distinct declining trends for TCE and cDCE. The slightly increasing VC trend likely is due to biodegradation of TCE and DCE to VC. Based on the observed trends in these wells, it appears likely that the concentrations in well 0524 will return to near non-detect levels over the next few years.

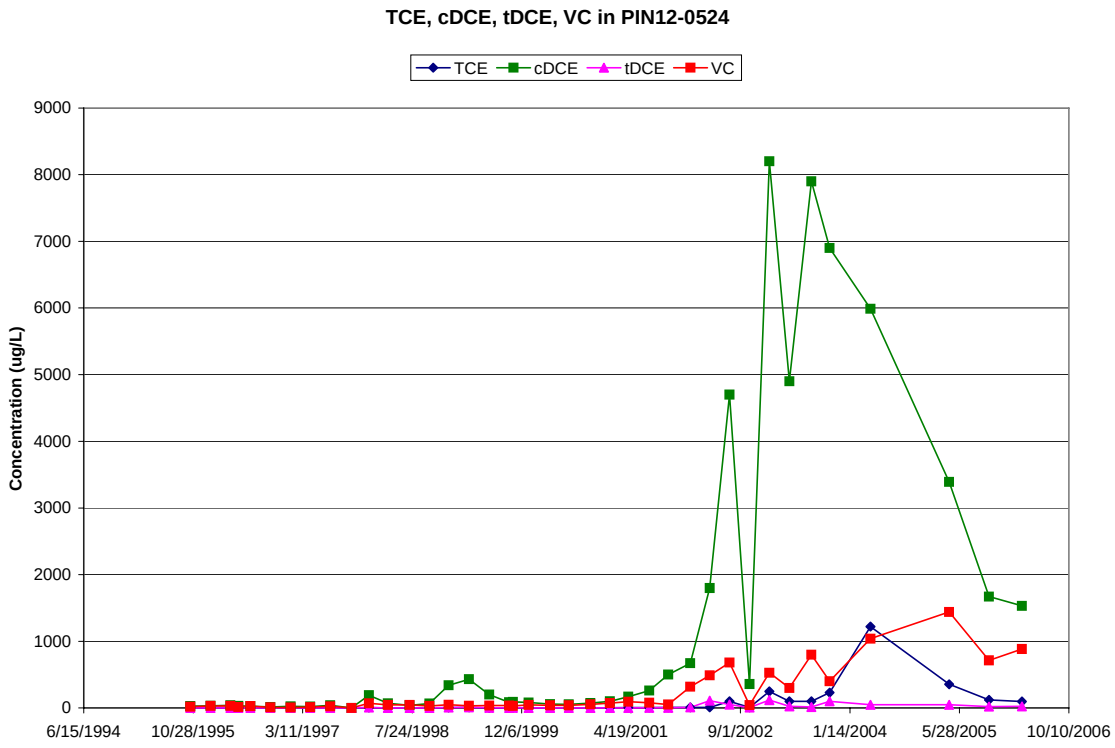

Figure A−16. TCE, cDCE, tDCE, and VC in PIN12−0524

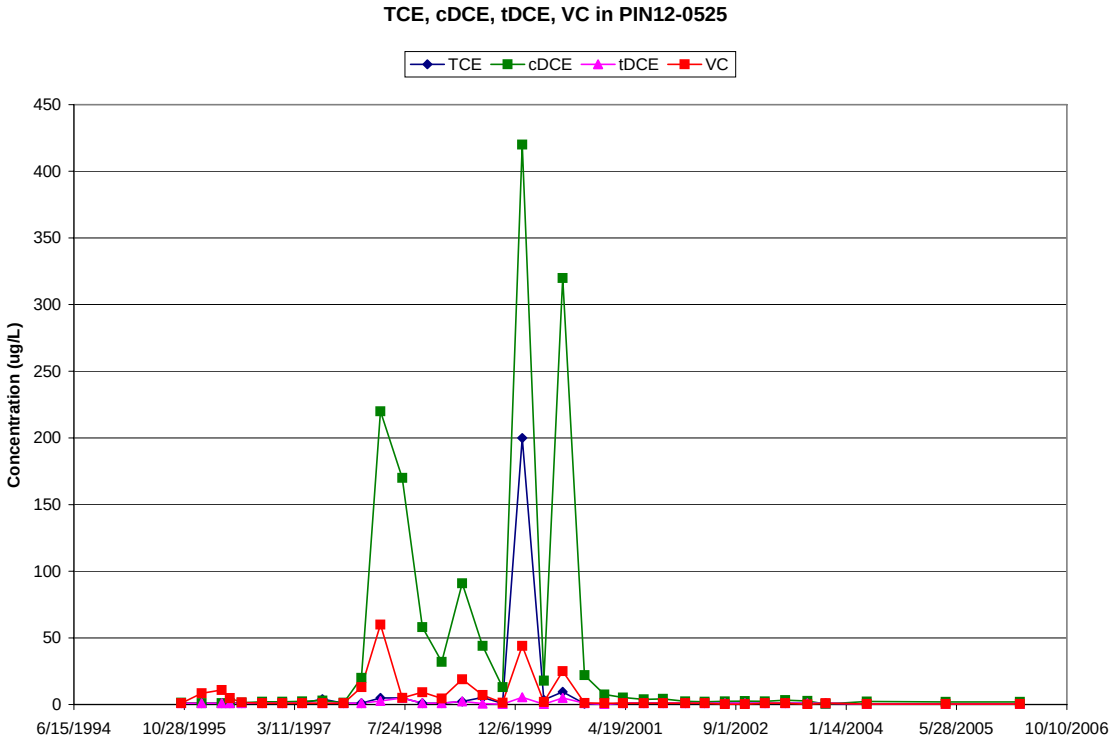

Figure A−17. TCE, cDCE, tDCE, and VC in PIN12−0525

Wells PIN12−S68B, −S68C, and –S68D are located southeast of wells 12−0524 and –0525. COPCs have never been detected in well S68B. Wells S68C and S68D show consistent concentration trends (Figures A−18 and A−19). The cDCE and VC trends in S68C actually show an increasing trend, but the increase is from <2 µg/L to <6 µg/L, a change that is well within the range of variability that could be caused by sampling and analysis, therefore the conclusion that the trends in this well are stable. The trends in well S68D have shown some variability over time, but the concentrations over the last 2 years are almost identical to the concentrations in 2002 when the well was first sampled.

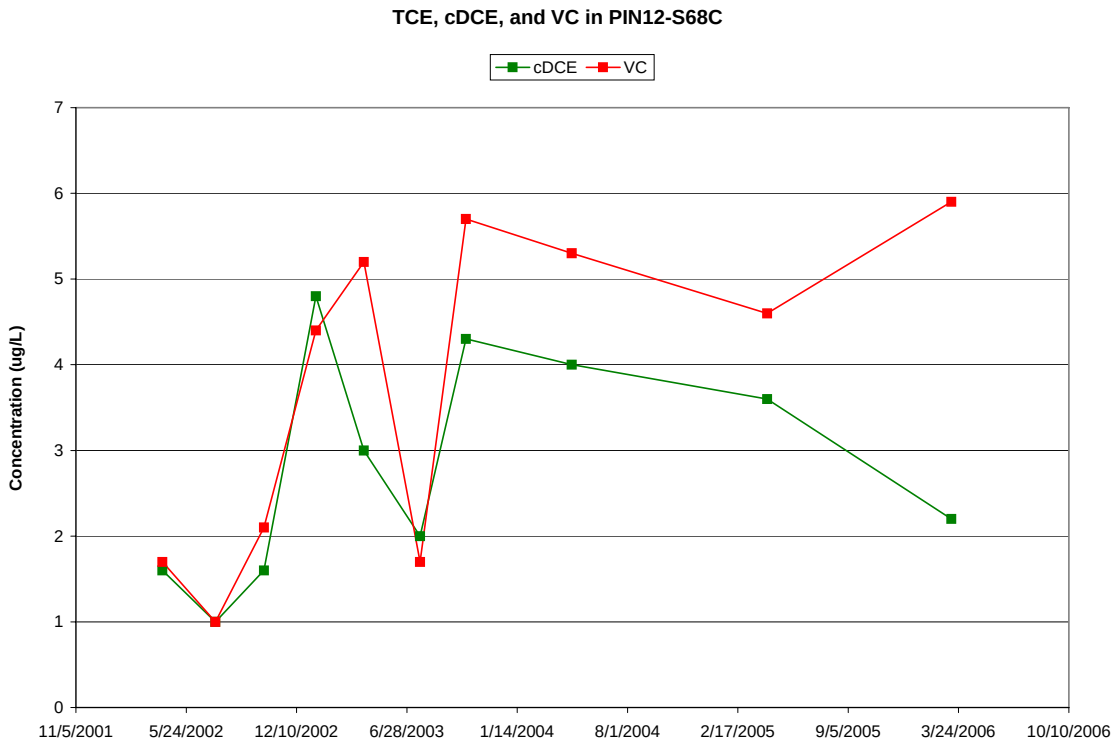

Figure A−18. TCE, cDCE, and VC in PIN12−S68C

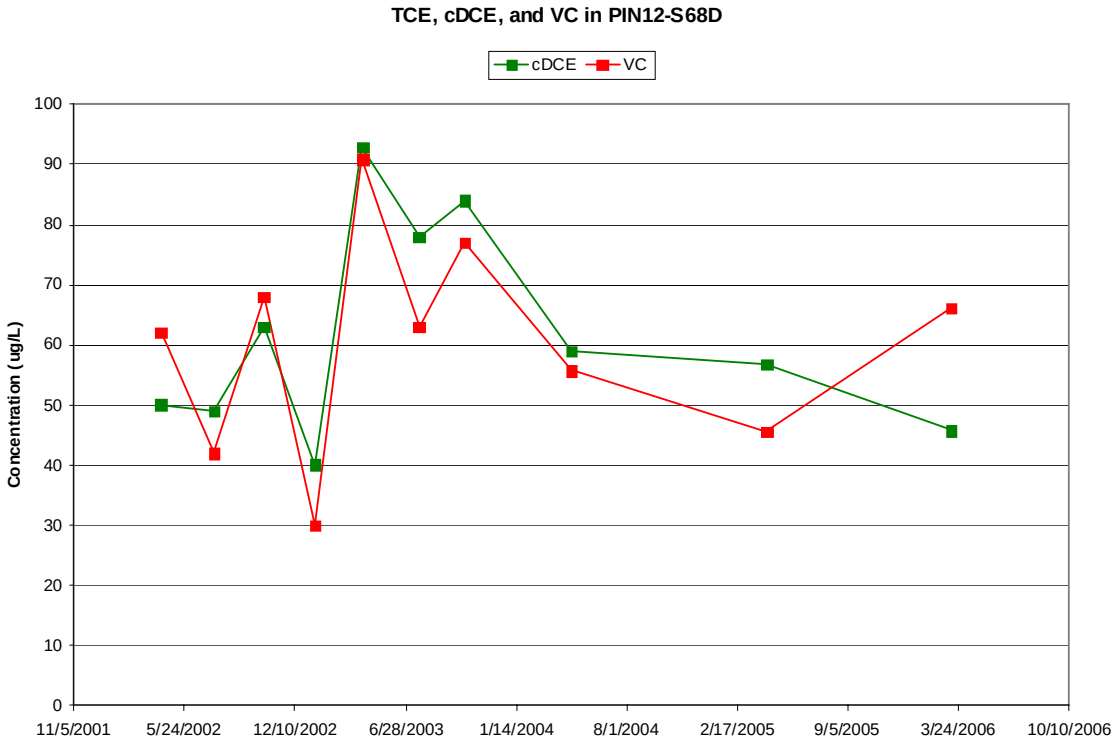

Figure A−19. TCE, cDCE, and VC in PIN12−S68D

Wells PIN12−S69B, −S69C, and −S69D are located east of the S68 wells. Well S69B has never shown COPCs detections and well S69D has shown a few cDCE detections <2 µg/L. Well S69C has shown only a few detections of cDCE and VC, with VC above the MCL only in April 2004 at 1.1 µg/L, and at the 1 µg/L MCL in March 2006 (no figure).

Well PIN21−0512 is located along the southern property boundary south of the S68 wells. This well has shown consistent cDCE and VC trends, within the range of analytical and sampling variability (Figure A−20). VC concentrations have ranged from <0.5 µg/L to 8.6 µg/L since 1998, and cDCE concentration have ranged from <0.5 µg/L to 6.1 µg/L since 1998.

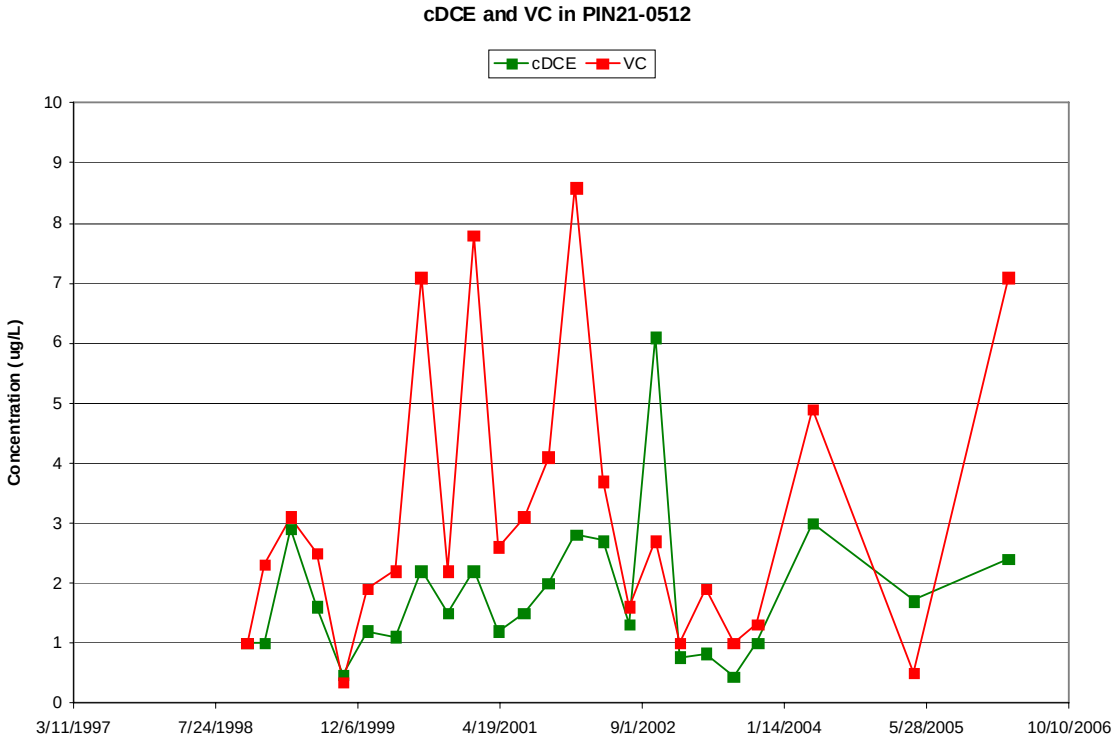

Figure A−20. cDCE and VC in PIN21−0512

Wells PIN21−0502 and –0503, located at the southeast corner of the property, have never shown detections of any COPCs (no figure). These wells likely define the farthest possible downgradient extent of the COPC plume. Based on the fact that contaminants have been detected at consistent concentrations in the wells that are far downgradient (21−0512 and 12−S73C), and yet has never appeared in wells 0502/0503 which are slightly farther downgradient, the leading edge of the plume is somewhere between wells 0502/0503 and the wells with contaminant detections. Apparently natural attenuation processes act on the plume such that contaminant concentrations fall below the detection limit (and thus below the MCLs) before the plume reaches the wells 0502/0503 area. This is a significant indicator that the plume is not expanding and, therefore, is stable.

Arsenic is a relatively recent addition to the COPCs list for the Building 100 Area, and currently is monitored in only nine wells that contain arsenic above the 10 µg/L MCL. Arsenic concentrations in these wells have remained relatively constant or have decreased since routine arsenic sampling started in January 2002 (Figure A−21). In addition to these nine wells, six other wells were dropped from the arsenic sampling list for fiscal year 2006 following an evaluation of fiscal year 2005 arsenic data. These six wells had previously contained arsenic concentrations above the MCL, but none of these wells contained arsenic above the MCL during four quarters of data in fiscal year 2005, indicating a distinct decreasing trend for arsenic in these wells. Arsenic tends to sorb to solids, and therefore is transported very slowly in the subsurface. Arsenic has not been detected in any wells near the property boundary.

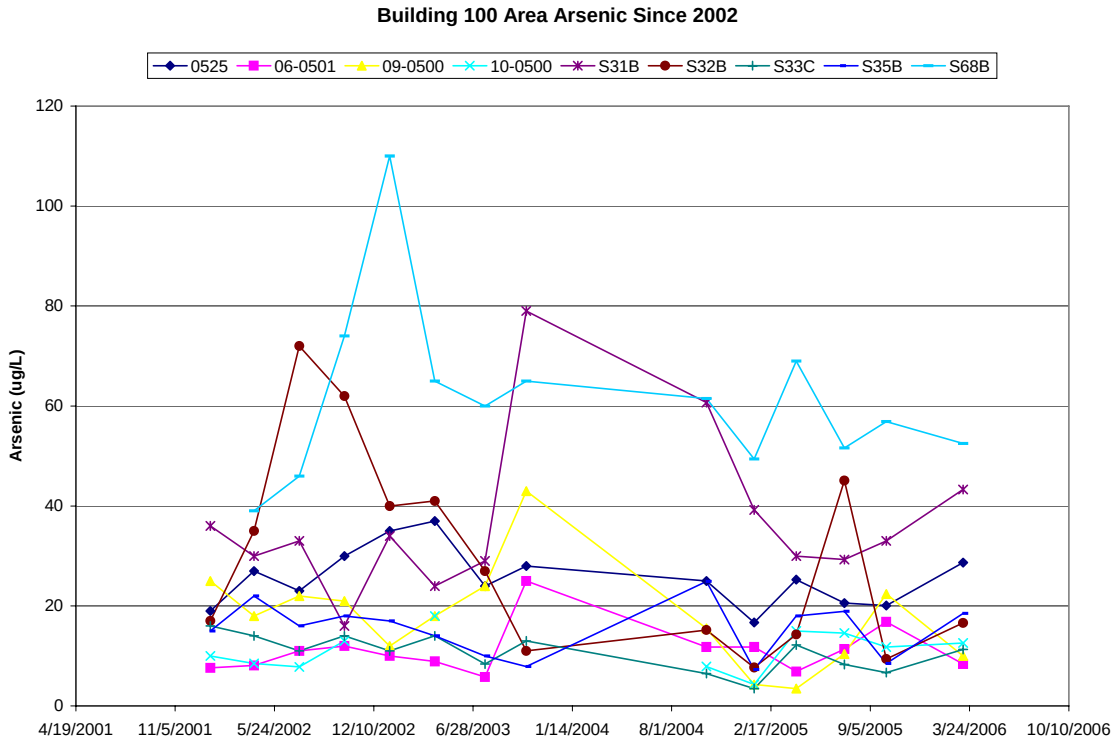

Figure A−21. Building 100 Area Arsenic Since 2002

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