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ADDENDUM NO. 1
TO THE
PRELIMINARY DESIGN REPORT
FOR THE
GROUNDWATER REMEDIAL ACTION
REVISION 0
ISSUED MAY 8, 2001

CRAB ORCHARD NATIONAL WILDLIFE REFUGE
PCB OPERABLE UNIT - SITES 32/33
MARION, ILLINOIS

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Table of Contents

1. Background 1

2. Estimation Methods and Assumptions 2
   2.1 Estimation of Total VOC Mass 2
   2.2 Estimation of Potential VOC Mass Removal 3

3. Summary of Estimates 5

List of Tables

Table 1 Estimated VOC Mass in Source Areas and Potentially Recoverable Mass Using MPE Technology 6

List of Figures

Figure 1 Estimated VOC Recovery at Building I-1-2 Source Area
Figure 2 Estimated VOC Recovery at Building I-1-3 Source Area
Figure 3 Estimated VOC Recovery at Building I-1-23 Source Area
Figure 4 Estimated VOC Recovery at Repository Source Area (SB-411 Treatment Zone Only)

Section 1
Background

The Preliminary Design Report for the Groundwater Remedial Action - Revision 0 for Sites 32/33 at the PCB Operable Unit was issued on 8 May 2001. Preliminary review comments on the report were provided by the U.S. Fish and Wildlife Service (F&WS) on 23 May 2001. At the request of the United States Environmental Protection Agency (USEPA), a conference call was held on 24 May 2001 with representatives of the USEPA, the Illinois Environmental Protection Agency, F&WS, RMT, and Schlumberger (Cliff Kirchof of Kestrel Management Services, L.L.C.), to discuss the preliminary review comments from F&WS. During the conference call, it was agreed that RMT would develop additional information to supplement the Preliminary Design Report. The additional information requested includes estimates of the total volatile organic compound (VOC) mass present in each of the primary VOC source areas, and the VOC mass removal that is estimated to be achievable at each VOC source area using multi-phase extraction (MPE) and soil vapor extraction (SVE) technology. This Addendum No. 1 to the Preliminary Design Report provides the additional VOC mass estimates as requested during the conference call on 24 May 2001.

Section 2
Estimation Methods and Assumptions

2.1 Estimation of Total VOC Mass

The mass of total VOCs present in the soil within the VOC source areas was estimated using computer software known as Environmental Visualization System (EVS) Pro, sold by C Tech Development Corporation, Huntington Beach, California. EVS software was used to provide 3-D interpolation and geostatistical analysis of the VOC mass in each source area using a process called kriging. The USEPA has recognized kriging as a method for interpolation and extrapolation of environmental data such as contaminant concentrations in groundwater and soil. The USEPA has also published an evaluation of the EVS software (Environmental Technology Verification Report - Environmental Visualization System Pro [EVS-Pro], EPA/600/R-00/047, March 2000).

The key input data used with the EVS software were the laboratory results for VOC concentrations in the 377 soil samples collected in fall 2000 at the VOC source areas. The samples were collected from saturated as well as unsaturated soil. Other input data included physical characteristics of the various soil units found at each source area (Upper Clay - UC, Upper Sand - US, Lower Clay - LC), physical properties of the VOCs, and the elevations of the interface between the geologic units and the groundwater table. With these input data, the EVS software was able to provide the estimated mass of total VOCs within each geologic unit at the VOC source areas. The estimates include the total VOC mass (dissolved and adsorbed) in soil with total VOC concentrations greater than 1 mg/kg (wet weight or "as-is" basis).

Several variables associated with this estimation method result in significant uncertainty with regard to the total VOC mass present in the subsurface as well as the total mass that is potentially recoverable by MPE. These variables are as follows:

- **Discrete sampling** - Over 370 soil samples were collected and analyzed. However, each of these samples, which are smaller than the size of a thumb, represents a discrete data point separated by horizontal and vertical distances of tens to hundreds of feet from the next data point. Although this is the accepted approach to cost-effectively defining the nature and extent of contamination in soil, it has inherent limitations. Due mostly to soil heterogeneity, it is possible to miss localized hot spots, or largely clean zones, and thereby miscalculate the total amount of mass using interpolation techniques. In addition, the spatial variability of VOC concentrations will be greatest in the soil zones with the higher concentrations, thereby increasing the difficulty in developing accurate VOC mass estimates in the soil zones targeted for MPE treatment.

- **Limited samples to define lateral limits of source areas** - The edges of the VOC source areas are either defined by a relatively "clean" boring, or they are estimated by extrapolation from the nearest boring where VOCs were present. Similar to the issue discussed above, this technique, although applied and checked by experienced hydrogeologists using professional judgment, could result in estimates of mass that differ from the actual amount in the subsurface.
- **Soil physical parameters** - Soil samples were collected and analyzed for physical parameters. Relatively few samples were collected (less than 10 total for all areas); but the results from the samples were not highly variable from area to area, except for the Upper Sand unit at Building I-1-23. However, these samples, slightly larger than a can of soda, are representative of the soil matrix at that specific localized point, not necessarily the bulk formation surrounding it. Variability in parameters such as permeability/hydraulic conductivity can be expected, due mostly to soil heterogeneity.

2.2 Estimation of Potential VOC Mass Removal

The total VOC mass that could potentially be removed from the treatment zone at each source area using MPE well systems was also estimated. The "treatment zone" is defined as the VOC-impacted soil zone that is expected to be affected by the MPE well system. These estimates were based on the available soil and groundwater chemistry data, soil physical data, site conditions, results of MPE pilot tests performed in fall 2000, and engineering assumptions and judgement. The following key factors were considered in developing the mass removal estimates:

- Approximate percentage of VOCs in the groundwater (dissolved phase) and in the soil (adsorbed phase) in each treatment zone
- Soil capillary tension/moisture relationships for each of the three unconsolidated units (UC, US, LC)
- Removal of dissolved-phase VOC mass by the "flushing" action of additional pore volumes of groundwater that move through the treatment zone due to the hydraulic gradient created by the MPE wells
- Removal of VOC mass by volatilization created by induced soil vapor movement through soil pores that may be dewatered during the MPE operating period

An estimated range of potential VOC mass removal as a percentage of total VOC mass in each treatment zone using MPE wells was developed for each of the three soil units (UC, US, LC). Estimates of potentially recoverable VOC mass using MPE were also prepared using the pilot test data. The data include air flow, groundwater flow, and VOC analysis of air and water samples. The data were extrapolated using assumptions based on published information, modeling results, experience from other sites, and professional judgment. The following

assumptions were common to all four source areas (Buildings I-1-2, I-1-3, and I-1-23, and the Repository):

1. For the initial operating period when the formation is being "dewatered" to the extent possible (a duration of 50 to 75 days in the clay; 5 days in the sand), the VOC vapor recovery data from the MPE pilot test were extrapolated using a "best fit" logarithmic curve. For the Building I-1-2 and I-1-3 areas, and the area near SB-423 (at the Repository), the vapor-phase VOC recovery data were assumed to be proportional to concentrations at the Repository during the pilot test, dependent on VOC concentrations in groundwater in wells closest to each respective area. The vapor-phase air flow is primarily aspiration or atmospheric "bleed" air metered into the MPE wells to induce air/water extraction, as described in the Preliminary Design Report.
2. After "dewatering" to the extent possible is achieved, the vapor-phase recovery rate is reduced by 80% within the next 20 days of operation. This is typical with many MPE and SVE systems (Engineering and Design, Soil Vapor Extraction and Bioventing, Engineer Manual 1110-1-4001, U.S. Army Corps of Engineers, November 1995).
3. From that point, a "best fit" exponential curve is assumed, to show an asymptotic decline to 0 lb. VOCs/day.
4. A constant, but low, VOC mass recovery rate in groundwater during the entire duration of operation is estimated, assuming continuous dewatering due to lateral recharge and flushing for 2 years.
5. The total VOC mass removal over a 2-year operating period is calculated by summing the mass removal in the vapor phase and in the extracted groundwater.

For the Upper Sand layer at Building I-1-23, the following additional assumptions were used:

1. The VOCs removed in the vapor phase from the Upper Sand will be 30% of the average VOC vapor-phase concentration from the Upper Clay unit.
2. The sustained VOC mass recovery rate in the extracted groundwater is 50% of the average rate from the pilot test.

Graphs showing the approximate estimated VOC mass recovery rate over time at the Building I-1-2, I-1-3, I-1-23, and Repository source areas are shown on Figures 1 through 4, respectively.

Section 3
Summary of Estimates

The estimated ranges of total VOC mass removal that may be achievable within the separate soil units within the targeted soil treatment zones over 2 years of operation of the MPE well systems as configured in the Preliminary Design Report are as follows:

- 7 to 15% in the Upper Clay unit
- 45 to 70% in the Upper Sand unit
- 7 to 12% in the Lower Clay unit

A summary of the estimated total VOC mass in each source area, and the estimated VOC mass that could potentially be removed using the MPE well systems as configured in the Preliminary Design Report, is included in Table 1.

The recoverable VOC mass estimates extrapolated from the pilot test data as shown in Table 1, when evaluated with the estimated percent removal ranges for the various soil units, are inconsistent with the VOC mass present in each source area as estimated using the EVS software. The recoverable mass and removal efficiency estimates indicate that the EVS software likely underestimates the actual VOC mass present at each source area. The causes of this discrepancy are likely to be the estimation variables discussed in Section 2.

Notwithstanding the difficulties in developing accurate estimates of total VOC mass at the separate source areas, the more significant factor to consider in assessing the potential effectiveness of MPE technology (as configured in the Preliminary Design Report) in removing VOC mass is the "Estimated Removal Efficiency Range" for the separate soil units, as shown in Table 1. The overall effectiveness of the source removal facilities as presented in the Preliminary Design Report can also be assessed by considering the relative merits of removing approximately 500 pounds of VOCs from the environment, and/or by gauging the cost-effectiveness of the remedial action on the basis of the projected cost per pound of VOCs removed.

Table 1
Estimated VOC Mass in Source Areas and Potentially Recoverable Mass Using MPE Technology

AREA	SOIL UNIT	ESTIMATED VOC MASS IN OVERALL SOURCE AREA USING EVS SOFTWARE (lb)		ESTIMATED REMOVAL EFFICIENCY RANGE[1] (%)	ESTIMATED VOC MASS REMOVAL USING EXTRAPOLATED PILOT TEST DATA[2] (lb)
		(lb)	% OF TOTAL		
I-1-2	Fill	0.8	0.4	-- --	0
	UC	97.3	47.6	7 to 15	63.1[3]
	US	27.6	13.5	45 to 70	--
	LC	78.8	38.5	7 to 12	--
Totals		**204.5**	**100.0**	**-- --**	**63.1**
1-1-3	Fill	1.6	0.2	-- --	0
	UC	190.8	23.3	7 to 15	266.2[3]
	US	12.7	1.5	45 to 70	--
	LC	615.4	75.0	7 to 12	--
Totals		**820.5**	**100.0**	**-- --**	**266.2**
I-1-23	Fill	1.3	1.3	-- --	0
	UC	47.8	47.5	7 to 15	25.4[4]
	US	49.2	48.9	45 to 70	47.4
	LC	2.3	2.3	7 to 12	--
Totals		**100.6**	**100.0**	**-- --**	**72.8**
Repository[5]	Fill	9.7	1.4	-- --	0
	UC	522.0	77.0	7 to 15	107.8[4]
	US	NA	NA	NA	NA
	LC	146.5	21.6	7 to 12	--
Totals		**678.2**	**100.0**	**-- --**	**107.8**

Notes:

(1) VOC removal efficiency expressed as the estimated percent of the total VOC mass within the Treatment Zone that will be removed over 2 years of operation. Treatment zone is defined as the VOC-impacted soil zone that is expected to be affected by the MPE/SVE/groundwater extraction well systems.

(2) Over 2 years of operation.

(3) Combined UC, US, and LC. The Upper Sand is not continuous in this area. VOCs present in isolated sand lenses and stringers will be affected with the clay soil.

(4) Combined UC and LC.

(5) All mass values include two separate target treatment zones represented by soil borings SB-411 and SB-423.

NA = not applicable since Upper Sand unit not present in this area
UC = Upper Clay
US = Upper Sand
LC = Lower Clay
Fill = "clean" soil backfilled into PCB-soil excavations in 1996

Figure 1
Estimated VOC Recovery at Building I-1-2 Source Area

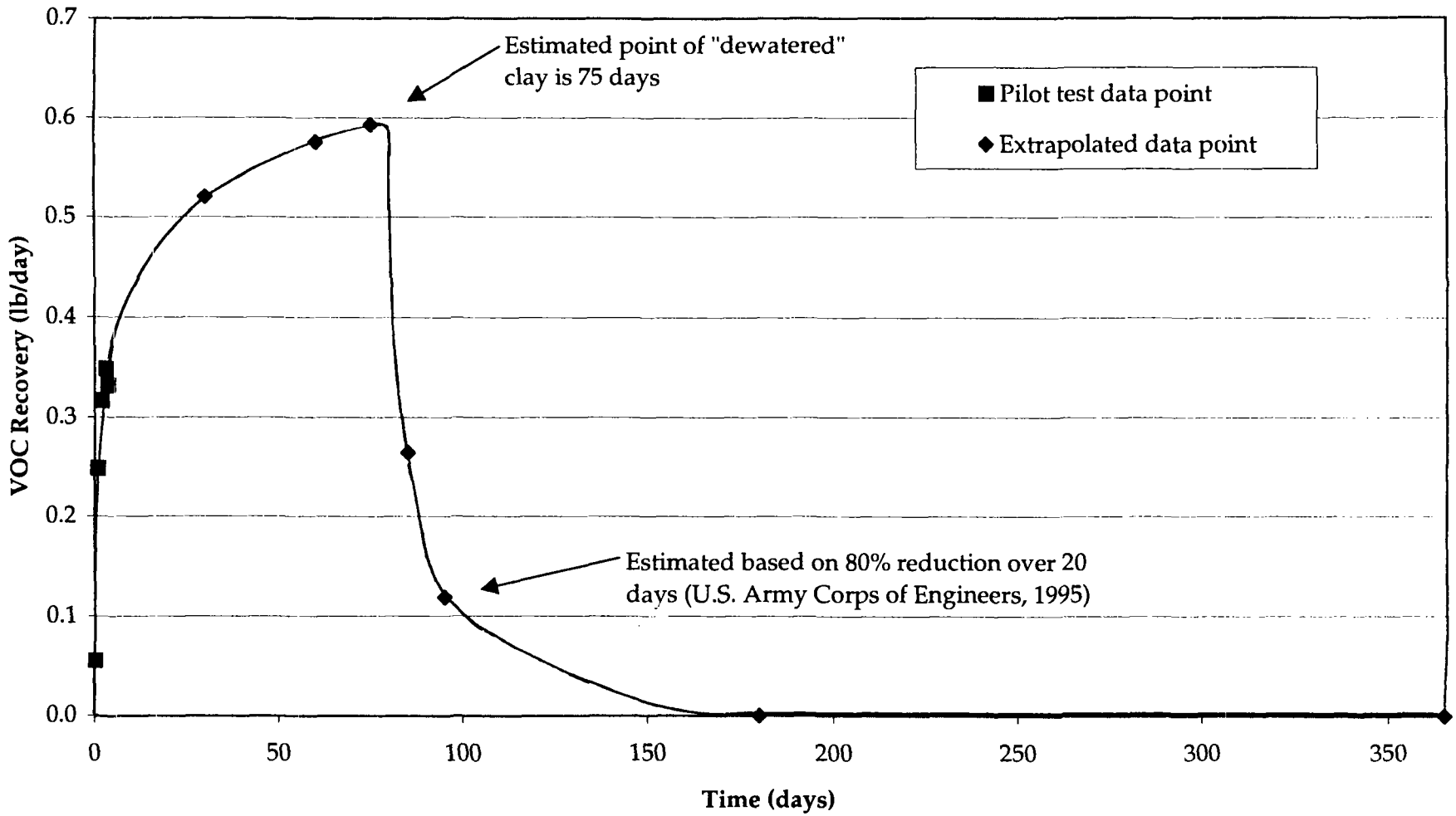

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Figure 2
Estimated VOC Recovery at Building I-1-3 Source Area

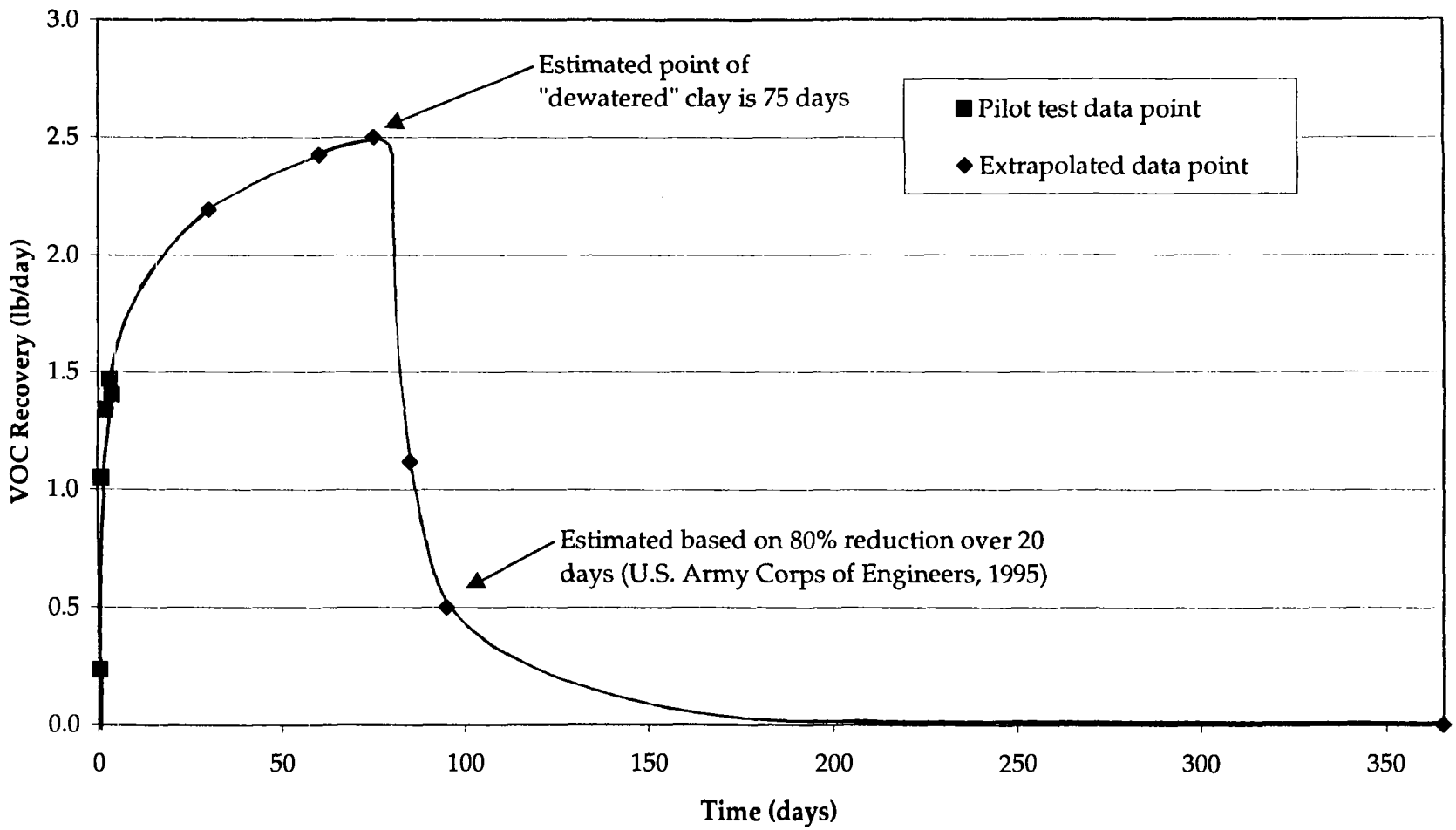

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Figure 3
Estimated VOC Recovery at Building I-1-23 Source Area

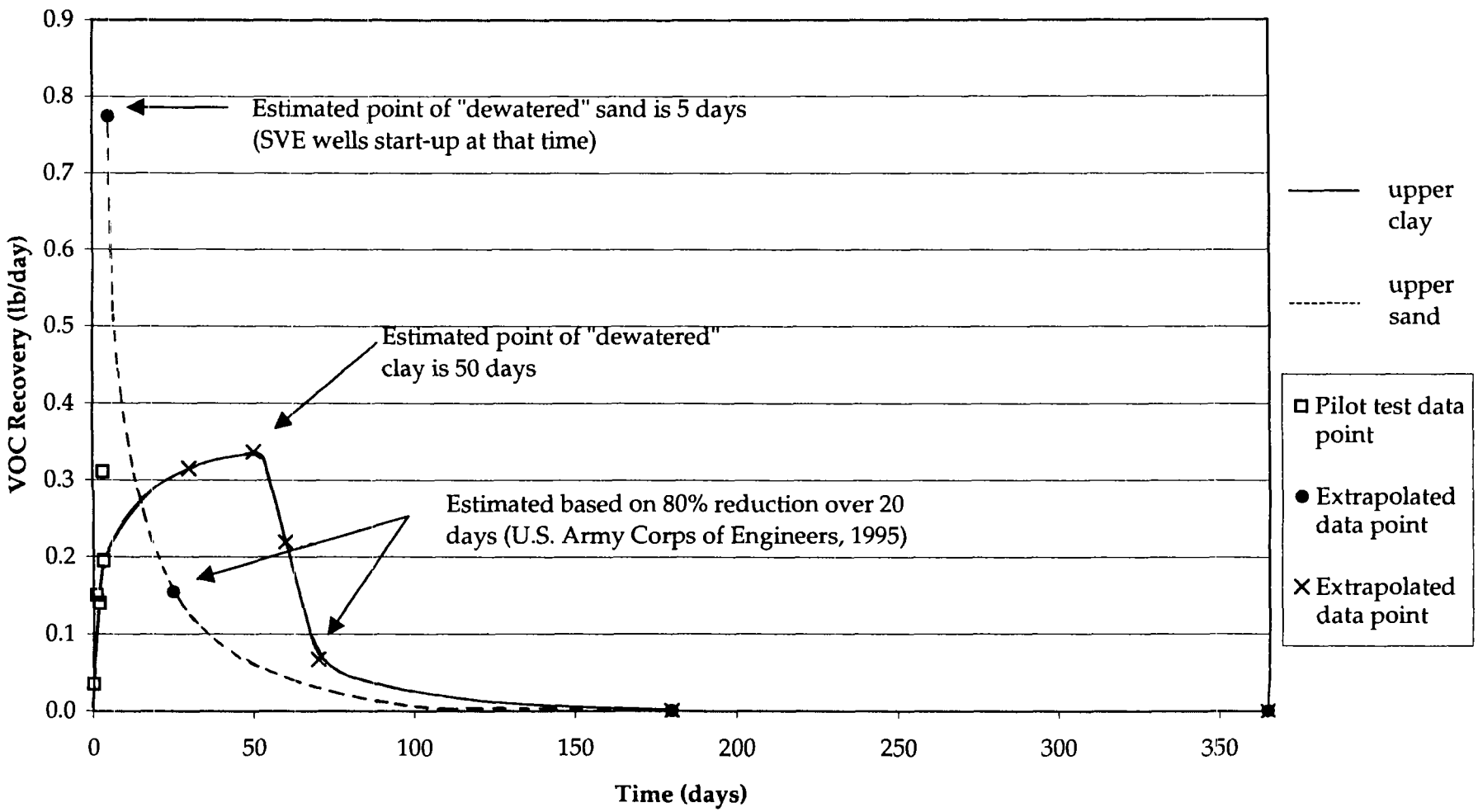

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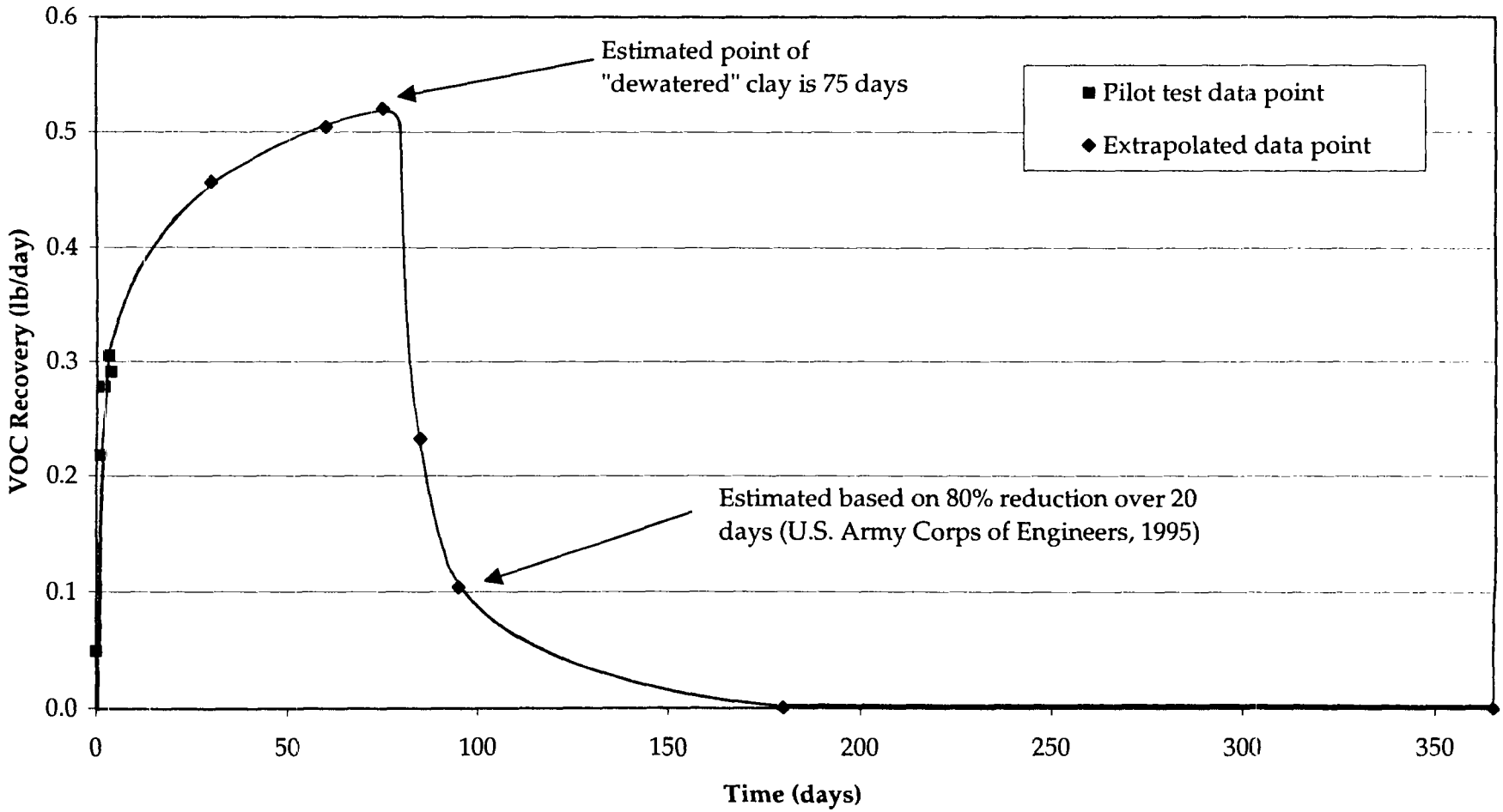
Figure 4
Estimated VOC Recovery at Repository Source Area
(SB-411 Treatment Zone Only) [1]



Note 1: Similar VOC recovery curve expected for soil treatment zone represented by soil boring SB-423.

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