GROUND-WATER CHEMISTRY NEAR U.S. AIR FORCE PLANT 59, JOHNSON CITY, NEW YORK: MAY AND SEPTEMBER, 1998

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INTRODUCTION AND BACKGROUND

Chlorinated hydrocarbons occur in ground water on and around Air Force Plant 59 near Johnson City, New York. These compounds likely came from now-discontinued industrial activities on Plant 59 and at private commercial establishments north of the Plant. The Air Force has for several years funded ground-water monitoring to define the concentrations, fate and sources of chlorinated hydrocarbons in the affected area.

Previous hydrologic studies (Coon et al., 1997) found that aquifers with a total saturated thickness of about 100 feet overlie shale bedrock in the vicinity of Plant 59 (Figures 1, 2). Within the Plant boundaries and to the immediate west, a lower unit of ice-contact deposits is separated from an upper unit of glacial outwash by low-permeability, fine-grained deltaic deposits (Figure 2a). North of Plant 59 in the vicinity of Azon Road, flood-plain alluvium at the surface overlies a thin unit of postglacial channel alluvium and thicker units of outwash, lake-bottom deposits and ice-contact deposits (Figure 2b). Close to the Susquehanna River, ice-contact deposits make up the entire saturated thickness. Ground water flows generally toward the river, southwesterly across Plant 59 and southerly from Azon Road (Figure 1).

Ground-water chemistry reflects the stratigraphy of the saturated units. Where a low-permeability fine-grained unit is present at intermediate depths, the uppermost aquifer contains oxygenated water whereas anoxic conditions prevail in the lowermost aquifer. Wells in the upper aquifer on and near Plant 59 include SW3, SW4, SW7 and URS-2S, and in the lower aquifer include DW3, DW4, DPW, and URS-2D. In the Azon Road area, all wells are in the upper aquifer, including Azon 2, Azon 6, and URS-10S. Near the Susquehanna River, the single unconfined aquifer of ice-contact deposits contains oxygenated water. Wells in this aquifer include URS-3D and Johnson City Municipal Well #2.

Chlorinated hydrocarbons of concern in the study area include: 1) trichloroethene (TCE); 2) *cis*-1,2-dichloroethene (DCE), a degradation product of TCE; 3) 1,1,1-trichloroethane (TCA); and 4) 1,1-dichloroethane (DCA), a degradation product of TCA. Occurrence of these compounds near Plant 59 has been linked to reduction potential in the aquifers. In areas where a multi-layer aquifer sequence is present, larger TCE and TCA concentrations have been found in the upper, aerobic aquifer whereas larger DCE and DCA concentrations were detected in the lower, anaerobic aquifer. These chemical variations support the idea that where TCE- and TCA-contaminated ground water moves from upper to lower aquifers, DCE and DCA are produced by anaerobic bacterial degradation of the parent compounds (R.M. Yager, personal communication, 1998).

Sampling in May and September, 1998 was undertaken to determine whether this concept was supported by additional chemical data. The sampling also was done to investigate whether there was significant seasonal variation in ground-water chemistry.

RESULTS

Four tables summarize the available chemical data. Table 1 lists the analytical results of the 1998 samplings. The data are grouped into analyses from wells in the upper, lower, and single aquifers. Table 2 summarizes chemical distinctions among groundwater chemistry in the upper, lower and single aquifers. Table 3 compares the concentrations of chlorinated hydrocarbons from the latest samplings with previous results from the same wells. Table 4 contains information about analytical reporting limits and holding times.

Quality control procedures included analysis of a distilled-water blank during the May sampling. The blank sample contained 0.6 µg/L of TCE and 1.3 µg/L of DCE. These detections resulted from contamination of the Nalgene carboys in which the distilled water was stored. To compensate for possible contamination of samples collected in May, 0.6 µg/L TCE and 1.3 µg/L DCE were subtracted from the measured concentrations of all samples. The contaminated carboys were discarded after the problem was discovered, and the September samples are unaffected.

Inorganic chemistry

The dominant cations in groundwater in the vicinity of Plant 59 are calcium and sodium. Alkalinity (primarily bicarbonate (HCO_3^-)) and chloride are the main anions, with sulfate a subordinate but significant anion. The inorganic chemistry of water in the upper aquifer is distinguished from that in the lower aquifer by several criteria (Table 2). On average, water in the upper aquifer has smaller concentrations of alkalinity, ferrous iron (Fe^{2+}) and manganese (Mn^{2+}), and larger concentrations of nitrate (NO_3^-) and dissolved oxygen. Reduction-oxidation potentials, as indicated by pε values, are generally larger in the upper aquifer.

Organic chemistry

Upper aquifer

SW3, SW4, SW7, URS-2S, Azon 2, Azon 6 & URS-10S

Average TCE concentrations in upper-aquifer wells were 4.5 µg/L in May and 3.7 µg/L in September (Tables 2a, b). The largest TCE concentrations of 15 and 17.4 µg/L were in well SW4, which is near a former plating room on Plant 59. Average TCA concentrations were 10 µg/L in May and 1.3 µg/L in September. In May, the largest TCA concentration of 49.0 µg/L was in well Azon 6, which is south of a site of suspected contamination near Field Street. In September, the largest TCA concentration was 3.4 µg/L in well URS-3D. Average DCE concentrations in the upper aquifer were 1.0 µg/L in May and 2.3 µg/L in September. The largest concentrations were in well SW4, which contained 4.0 µg/L in May and 9.1 µg/L in September. Average DCA concentrations in the upper aquifer were 0.7 µg/L in May and 1.8 µg/L in September. The largest concentrations were in well SW4, which contained 2.4 µg/L in May and 9.1 µg/L in September. Average dissolved organic carbon concentrations in the upper aquifer were 0.6 mg/L in May and 0.8 mg/L in September.

Lower aquifer

DW3, DW4, DPW, & URS-2D

Average TCE concentrations in lower-aquifer wells were 1.0 µg/L in May and 0.8 µg/L in September (Tables 2a, b). The largest TCE concentrations of 2.6 and 3.4 µg/L were in well DPW, a production well downgradient of well pair SW4/DW4 on Plant 59. Average TCA concentrations were 0.8 µg/L in May and 0.2 µg/L in September. The largest TCA concentrations were 3.0 µg/L in well Azon 2 in May and 0.6 µg/L in well DPW in September. Average DCE concentrations in the lower aquifer were 6.4 µg/L in May and 8.0 µg/L in September. The largest concentrations were 18.7 and 24.0 µg/L in well DW3. Average DCA concentrations in the lower aquifer were 1.3 µg/L in May and 0.6 µg/L in September. The DCA largest concentrations were 4.9 µg/L and 1.6 µg/L in well Azon 2. Average dissolved organic carbon concentrations in the lower aquifer were 0.3 mg/L in May and 0.2 mg/L in September.

Single aquifer near the Susquehanna River

URS-3D & Johnson City Municipal Well #2

Average TCE concentrations in the single aquifer were 0.3 µg/L in May and 1.3 µg/L in September (Tables 2a, b). Maximum concentrations were 0.6 and 2.0 µg/L in well URS-3D. Average TCA concentrations were 1.5 µg/L in May and 3.4 µg/L in September. The largest concentrations were 2.9 and 3.4 µg/L in well URS-3D. The average DCE concentration was 0.1 µg/L in May and 1.0 µg/L in September; average TCA concentrations were 0.4 µg/L in May and 0.3 µg/L in September. Average dissolved organic carbon concentrations in the single aquifer were below detection levels in May and 0.4 mg/L in September.

COMPARISONS WITH HISTORICAL OCCURRENCES

Chlorinated hydrocarbon analyses from eight samplings of the wells in the vicinity of Plant 59 are available from November, 1991 to Sepember, 1998. Schematic flowpaths for ground water across USAF Plant 59 and in the vicinity of Azon Road are shown by the arrows in Figures 2a and 2b. The flowpath across Plant 59 extends from shallow well SW4 to deep wells DPW, DW3, URS-2D, URS-3D and Johnson City Municipal Well #2. The flowpath from Azon Road extends from shallow wells Azon 6, Azon 2 and URS-10S to deep well Johnson City Municipal Well #2.

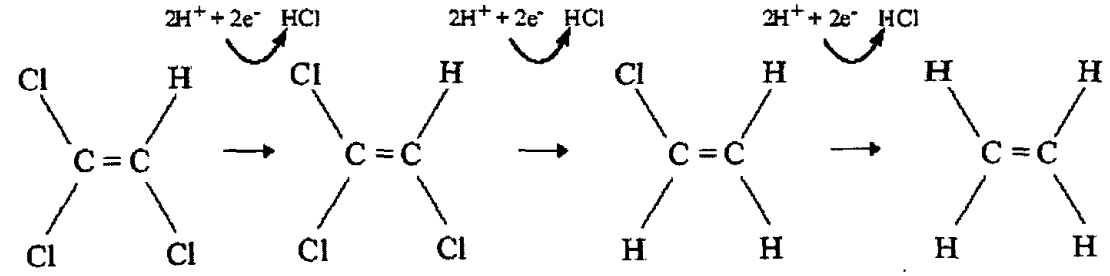
The largest TCE concentrations are always found in shallow ell SW4 at the beginning of the flowpath across Plant 59 (Figure 3a). Concentrations farther along the flowpath are very small or less than detection limits. DCE is found in all wells along the flowpath and are least in wells URS-3D and Johnson City Municipal Well #2 (Figure 3b). DCE concentrations measured in May and September, 1998 tend to be smaller than or comparable to previously measured concentrations, with the exception that DCE was detected in Johnson City Municipal Well #2 where it had not been previously found. TCA concentrations along the flowpath from Azon Raod are largest in the first well, Azon 6 (Figure 3c). TCA concentrations in May and September 1998 were small or below detection limits. DCA was absent from well Azon 6 in all samplings, and concentrations were small in May and September 1998.

INTERPRETATION

Inorganic chemical indicators show that water in the upper aquifer is aerobic compared to water in the lower aquifer, which is more a reducing environment. Water in the upper aquifer contains comparatively smaller Fe^{2+} and Mn^{2+}concentrations and larger dissolved-oxygen concentrations and redox (pε) values. Another chemical distinction between the two aquifers is larger alkalinities in the lower anaerobic aquifer. Alkalinity, which represents dissolved inorganic carbon, accumulates in solution from microbially mediated reactions such as denitrification and reduction of Mn^{4+} and Fe^{3+}.

The chemical distinctions between water chemistry in the upper and lower aquifers extend to chlorinated organic compounds. In May and September, average TCE and TCA concentrations in the upper aquifer were larger than those in the lower aquifer, and average DCE concentrations were larger in the lower aquifer than the upper aquifer (Tables 2a, b). Average DCA concentrations were larger in the lower aquifer in May, but larger in the upper aquifer in September due to a detection of 9.1 µg/L in well SW4. The larger concentrations of TCE and TCA in the upper aquifer, and larger concentrations of DCE and, in May, of DCA in the deeper aquifer suggest that the parent trichlorinated compounds (TCE, TCA) were reduced to dichlorinated compounds (DCA and DCE) under anaerobic conditions in the lower aquifer.

The anaerobic pathway of TCE degradation is (Ellis, 1998):



This reductive pathway involves transfer of electrons to the chlorinated compounds and substitution of a hydrogen for a chlorine atom. The electron donor for dechlorination may be dissolved organic carbon, as possibly supported by smaller dissolved organic carbon concentrations in the lower aquifer compared to those in upper aquifer. Vinyl chloride was detected only in well SW4 in September at a concentration of 0.6 µg/L, and no ethene was detected in any well. However, the lack of detectable of ethene may be because reductive dechlorination of vinyl chloride to ethene occurs at a slow rate and only at very reducing conditions (Wilson et al., 1995). Furthermore, chlorinated organic compounds can sorb strongly to aquifer solids (Swaboda-Colberg, 1995) and plant materials (Welke et al., 1998), so it is possible that vinyl chloride was produced by anaerobic degradation of TCE in wells other than SW4 but was not detectable in solution.

Under aerobic conditions, vinyl chloride can biotically degrade to carbon dioxide (Bradley and Chappelle, 1998). This reaction has been shown to occur at dissolved-oxygen concentrations of 2 to 6 mg/L, which generally the match the concentrations in

the upper and single aquifers (Tables 1a, b). This reaction provides a possible explanation for the absence of vinyl chloride in upper-aquifer wells.

With certain exceptions, concentrations of chlorinated compounds in most wells did not differ greatly in May and September (Figures 3a, b). In well SW4, TCE concentrations decreased from 17.6 µg/L in May to 15.0 µg/L in September (Figure 3a). Correspondingly, DCE concentrations increased from 4.0 µg/L in May to 9.1 µg/L in September. Similar changes in TCA and DCA concentrations occurred in well SW4 (Figure 3b). These patterns are consistent with reductive dechlorination in well SW4 between May and September. Concentrations of TCE in upper-aquifer well Azon 6 decreased from 3.8 mg/L in May to 0.4 mg/L in September, and TCA concentrations decreased from 49 mg/L in May to 0.5 mg/L in September. The explanation for these decreases are uncertain.

CONCLUSIONS

The chlorinated hydrocarbons TCE and TCA, and their daughter products, persist in ground water near Air Force Plant 59. In general, concentrations of these compounds detected in May and September, 1998 are smaller than or comparable to those found in previous samplings since 1991. Where ground water is anaerobic, as indicated by inorganic chemical parameters, TCE and TCA concentrations tend to decrease whereas DCE and DCA concentrations tend to increase. This pattern is consistent with anaerobic bacterially mediated degradation of the chlorinated organics.

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Table 1a. Groundwater chemistry on and near U.S. Air Force Plant 59, Johnson City, NY - May 4-7, 1998

[ND, not detected; mg/L, milligrams per liter, µg/L, micrograms per liter, µS/cm, microSiemens per centimeter, °C, degrees Centigrade]

Field measurements

	Well name	Date	Time	Temperature (°C)	pH	Alkalinity (mg/L as $CaCO_3$)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	Fe^{2+} (mg/L)	S^{2-} (mg/L)
Upper aquifer	SW3	5/7/98	10:00	9.6	7.10	242	1178	3.9	0.1	ND
	SW4	5/7/98	12:47	18.5	7.09	246	1358	2.0	0.0	0.0
	SW7	5/7/98	14:30	15.5	7.38	294	1666	5.8	0.0	ND
	URS-2S	5/4/98	14:30	14.2	7.11	264	1490	5.3	0.1	ND
	Azon 2	5/4/98	18:30	11.8	6.77	336	1670	0.0	2.6	0.1
	Azon 6	5/5/98	8:30	11.6	7.00	292	1317	3.0	0.0	0.0
	URS-10S	5/4/98	16:40	12.1	6.87	292	1294	0.2	0.0	0.0
Lower aquifer	DW3	5/7/98	9:30	13.4	7.20	308	1361	0.1	0.7	ND
	DW4	5/7/98	11:45	13.8	7.29	308	1348	0.1	0.3	ND
	DPW	5/7/98	15:00	14.1	7.28	326	1495	0.0	0.2	0.0
	URS-2D	5/4/98	14:00	13.4	7.16	306	1117	0.1	0.9	0.0
Single aquifer	URS-3D	5/4/98	9:30	11.7	6.96	296	1340	1.2	0.1	0.0
	Johnson City #2	5/4/98	11:30	11.9	7.96	212	947	10.3	0.0	ND

Laboratory measurements - inorganic constituents

	Well name	Date	Time	Aluminum (mg/L)	Barium (mg/L)	Boron (mg/L)	Calcium (mg/L)	Chromium (mg/L)	Total iron (mg/L)	Magnesium (mg/L)
Upper aquifer	SW3	5/7/98	10:00	ND	0.1	ND	132.0	0.0	ND	20.2
	SW4	5/7/98	12:47	ND	0.1	ND	128.0	0.1	ND	21.2
	SW7	5/7/98	14:30	ND	0.1	ND	154.0	0.0	ND	25.5
	URS-2S	5/4/98	14:30	ND	0.1	ND	143.0	ND	ND	24.9
	Azon 2	5/4/98	18:30	ND	0.1	ND	137.0	ND	2.4	28.6
	Azon 6	5/5/98	8:30	ND	0.1	ND	118.0	ND	ND	25.1
	URS-10S	5/4/98	16:40	ND	0.1	ND	124.0	ND	ND	23.7
Lower aquifer	DW3	5/7/98	9:30	ND	0.3	ND	162.0	ND	0.6	37.1
	DW4	5/7/98	11:45	0.1	0.1	ND	151.0	ND	0.3	36.3
	DPW	5/7/98	15:00	ND	0.1	ND	156.0	ND	0.2	33.6
	URS-2D	5/4/98	14:00	ND	0.1	ND	134.0	ND	0.8	32.1
Single aquifer	URS-3D	5/4/98	9:30	ND	0.1	ND	136.0	ND	ND	27.6
	Johnson City #2	5/4/98	11:30	ND	0.1	ND	97.6	ND	ND	17.4
	Equipment blank	5/7/98	10:15	ND	ND	ND	1.3	ND	ND	0.2

Table 1a, continued

Laboratory measurements - inorganic constituents

	Well name	Date	Time	Manganese (mg/L)	Sodium (mg/L)	Nickel (mg/L)	Silica (mg/L)	Antimony (mg/L)	Selenium (mg/L)	Tin (mg/L)
Upper aquifer	SW3	5/7/98	10:00	ND	69.1	ND	8.3	ND	ND	ND
	SW4	5/7/98	12:47	ND	108.0	ND	9.4	ND	ND	ND
	SW7	5/7/98	14:30	ND	135.0	ND	10.9	ND	ND	0.1
	URS-2S	5/4/98	14:30	0.0	103.0	0.1	9.2	0.0	0.0	0.0
	Azon 2	5/4/98	18:30	0.6	149.0	ND	6.4	ND	ND	ND
	Azon 6	5/5/98	8:30	ND	95.9	ND	6.2	ND	ND	0.1
	URS-10S	5/4/98	16:40	ND	89.3	ND	6.7	ND	ND	0.0
Lower aquifer	DW3	5/7/98	9:30	0.7	55.7	ND	10.6	0.0	0.1	ND
	DW4	5/7/98	11:45	0.7	63.9	ND	11.4	ND	0.1	0.0
	DPW	5/7/98	15:00	0.6	94.1	ND	10.9	ND	ND	0.0
	URS-2D	5/4/98	14:00	0.7	34.3	ND	11.7	ND	ND	0.0
Single aquifer	URS-3D	5/4/98	9:30	0.0	84.6	ND	10.5	0.0	ND	0.1
	Johnson City #2	5/4/98	11:30	ND	57.3	ND	8.0	ND	ND	ND
	Equipment blank	5/7/98	10:15	ND	ND	ND	ND	ND	ND	ND

	Well name	Date	Time	Chloride (mg/L)	Fluoride (mg/L)	Nitrate-N (mg/L)	Sulfate (mg/L)	Ammonia-N (mg/L)	Total Kjeldahl-N (mg/L)
Upper aquifer	SW3	5/7/98	10:00	172.0	ND	1.6	80.9	ND	ND
	SW4	5/7/98	12:47	237.0	ND	2.3	46.3	ND	0.4
	SW7	5/7/98	14:30	309.0	ND	2.6	59.4	ND	ND
	URS-2S	5/4/98	14:30	273.0	ND	2.1	59.7	ND	ND
	Azon 2	5/4/98	18:30	316.0	ND	ND	45.6	0.2	0.6
	Azon 6	5/5/98	8:30	227.0	ND	0.8	30.3	ND	ND
	URS-10S	5/4/98	16:40	205.0	ND	ND	39.8	ND	0.3
Lower aquifer	DW3	5/7/98	9:30	191.0	ND	ND	97.6	ND	0.5
	DW4	5/7/98	11:45	198.0	ND	ND	95.9	ND	ND
	DPW	5/7/98	15:00	228.0	ND	ND	86.3	ND	ND
	URS-2D	5/4/98	14:00	126.0	ND	ND	92.1	ND	ND
Single aquifer	URS-3D	5/4/98	9:30	214.0	ND	1.0	56.6	ND	ND
	Johnson City #2	5/4/98	11:30	137.0	ND	1.0	43.0	ND	ND
	Equipment blank	5/7/98	10:15	ND	ND	ND	ND	ND	ND

Table 1a, continued

Laboratory measurements - organic constituents

	Well name	Date	Time	Total organic carbon (mg/L)	Benzene (µg/L)	n-Butylbenzene (µg/L)	sec-Butylbenzene (µg/L)	Chloroethane (µg/L)	1,1-Dichloroethane (µg/L)	*Cis*-1,2-Dichloroethene (µg/L)
Upper aquifer	SW3	5/7/98	10:00	1.1	ND	ND	ND	ND	0.7	0.1
	SW4	5/7/98	12:47	ND	ND	ND	ND	ND	2.4	4.0
	SW7	5/7/98	14:30	1.2	ND	ND	ND	ND	ND	0.8
	URS-2S	5/4/98	14:30	ND	ND	ND	ND	ND	0.4	1.2
	Azon 2	5/4/98	18:30	1.4	1.0	2.1	1.1	ND	4.9	ND
	Azon 6	5/5/98	8:30	ND	ND	ND	ND	ND	ND	ND
	URS-10S	5/4/98	16:40	ND	ND	ND	ND	0.7	0.8	ND
Lower aquifer	DW3	5/7/98	9:30	ND	ND	ND	ND	ND	ND	18.7
	DW4	5/7/98	11:45	ND	ND	ND	ND	ND	ND	ND
	DPW	5/7/98	15:00	ND	ND	ND	ND	ND	1.6	10.7
	URS-2D	5/4/98	14:00	ND	ND	ND	ND	ND	ND	2.6
Single aquifer	URS-3D	5/4/98	9:30	ND	ND	ND	ND	ND	0.5	0.1
	Johnson City #2	5/4/98	11:30	ND	ND	ND	ND	ND	ND	ND
	Equipment blank	5/7/98	10:15	ND	ND	ND	ND	ND	ND	1.3

	Well name	Date	Time	1,1-Dichloroethene (µg/L)	Ethylbenzene (µg/L)	Isopropylbenzene (µg/L)	Naphthalene (µg/L)	n-Propylbenzene (µg/L)	Tetrachloroethene (µg/L)	Toluene (µg/L)
Upper aquifer	SW3	5/7/98	10:00	ND	ND	ND	2.1	ND	ND	ND
	SW4	5/7/98	12:47	0.5	ND	ND	ND	ND	0.8	ND
	SW7	5/7/98	14:30	ND	ND	ND	ND	ND	ND	ND
	URS-2S	5/4/98	14:30	ND	ND	ND	ND	ND	ND	ND
	Azon 2	5/4/98	18:30	ND	1.5	1.1	0.6	2.6	ND	ND
	Azon 6	5/5/98	8:30	1.7	ND	ND	ND	ND	ND	ND
	URS-10S	5/4/98	16:40	0.2	ND	ND	ND	ND	ND	ND
Lower aquifer	DW3	5/7/98	9:30	ND	ND	ND	1.1	ND	ND	ND
	DW4	5/7/98	11:45	ND	ND	ND	ND	ND	ND	ND
	DPW	5/7/98	15:00	0.4	ND	ND	ND	ND	0.2	ND
	URS-2D	5/4/98	14:00	ND	ND	ND	ND	ND	ND	ND
Single aquifer	URS-3D	5/4/98	9:30	ND	ND	ND	ND	ND	ND	ND
	Johnson City #2	5/4/98	11:30	ND	ND	ND	ND	ND	ND	ND
	Equipment blank	5/7/98	10:15	ND	ND	ND	ND	ND	ND	ND

Table 1a, continued

	Well name	Date	Time	1,1,1-Trichloroethane (µg/L)	Trichloroethene (µg/L)	Trichlorofluoromethane (µg/L)	1,2,4-Trimethylbenzene (µg/L)	Vinyl chloride (µg/L)	Total Xylenes (µg/L)
Upper aquifer	SW3	5/7/98	10:00	0.7	0.4	ND	ND	ND	ND
	SW4	5/7/98	12:47	3.7	17.4	1.1	ND	ND	ND
	SW7	5/7/98	14:30	1.6	2.5	ND	ND	ND	ND
	URS-2S	5/4/98	14:30	0.9	0.6	ND	ND	ND	ND
	Azon 2	5/4/98	18:30	3.0	1.4	ND	8.5	ND	0.5
	Azon 6	5/5/98	8:30	49.0	3.8	ND	ND	ND	ND
	URS-10S	5/4/98	16:40	2.2	1.8	ND	ND	ND	ND
Lower aquifer	DW3	5/7/98	9:30	ND	ND	ND	ND	ND	ND
	DW4	5/7/98	11:45	ND	ND	ND	ND	ND	ND
	DPW	5/7/98	15:00	1.2	3.4	ND	ND	ND	ND
	URS-2D	5/4/98	14:00	ND	ND	ND	ND	ND	ND
Single aquifer	URS-3D	5/4/98	9:30	2.9	0.6	ND	ND	ND	ND
	Johnson City #2	5/4/98	11:30	ND	ND	ND	ND	ND	ND
	Equipment blank	5/7/98	10:15	ND	0.6	ND	ND	ND	ND

Explanation: ND, not detected.

Table 1b. Groundwater chemistry on and near U.S. Air Force Plant 59, Johnson City, NY - September 22-30, 1998

[ND, not detected; mg/L, milligrams per liter, µg/L, micrograms per liter, µS/cm, microSiemens per centimeter, °C, degrees Centigrade]

Field measurements

	Well or sample	Date	Time	Temperature (°C)	pH	Alkalinity (mg/L as $CaCO_3$)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)	Fe^{2+} (mg/L)	S^{2-} (mg/L)
Upper aquifer	SW3	9/25/98	13:45	18.0	7.0	208	952	4.5	0.0	0.0
	SW4	9/28/98	10:30	18.4	6.9	254	903	2.9	0.0	0.0
	SW7	9/28/98	12:37	17.1	7.2	288	1166	0.4	0.0	0.0
	URS-2S	9/25/98	9:50	14.8	6.9	296	1340	1.6	0.0	0.0
	Azon 2	9/30/98	11:00	14.8	6.7	358	1273	0.0	0.9	0.1
	Azon 6	9/30/98	9:22	14.0	7.0	308	1384	1.3	0.0	0.0
	URS-10S	9/30/98	12:15	12.7	6.9	330	1258	0.2	0.0	0.0
Lower aquifer	DW3	9/25/98	12:35	13.5	6.9	316	1385	0.1	0.6	0.0
	DW4	9/28/98	9:15	13.9	7.0	312	1363	0.0	0.4	0.0
	DPW	9/28/98	13:21	13.3	7.3	289	1392	0.2	4.1	0.2
	URS-2D	9/25/98	8:35	13.4	6.9	314	1166	0.1	1.0	0.0
Single aquifer	URS-3D	9/22/98	10:30	12.2	6.9	306	1293	>0.8	0.0	0.0
	Johnson City #2	9/22/98	9:00	16.9	6.7	210	905	>0.8	0.0	0.0

Table 1b, continued

Laboratory measurements - inorganic constituents

	Well or sample	Date	Time	Calcium (mg/L)	Total iron (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Sodium (mg/L)	Silica (mg/L)
Upper aquifer	SW3	9/25/98	13:45	113.0	ND	15.8	ND	54.8	9.6
	SW4	9/28/98	10:30	97.4	ND	16.3	0.0	67.1	10.0
	SW7	9/28/98	12:37	129.0	ND	22.3	ND	70.9	11.9
	URS-2S	9/25/98	9:50	164.0	ND	27.5	0.1	75.3	11.5
	Azon 2	9/30/98	11:00	123.0	0.8	25.7	0.4	98.6	7.4
	Azon 6	9/30/98	9:22	135.0	ND	31.2	ND	98.0	7.9
	URS-10S	9/30/98	12:15	128.0	ND	25.6	0.1	91.9	8.8
Lower aquifer	DW3	9/25/98	12:35	166.0	0.6	38.9	0.8	61.0	11.6
	DW4	9/28/98	9:15	155.0	0.2	38.7	0.7	65.3	11.9
	DPW	9/28/98	13:21	147.0	1.7	35.5	0.7	81.0	11.5
	URS-2D	9/25/98	8:35	152.0	1.0	34.3	0.7	35.9	12.9
Single aquifer	URS-3D	9/22/98	10:30	146.0	ND	29.3	0.0	74.2	12.4
	Johnson City #2	9/22/98	9:00	104.0	ND	17.4	ND	53.6	9.4

	Well or sample	Date	Time	Chloride (mg/L)	Fluoride (mg/L)	Nitrate-N (mg/L)	Orthophosphate-P (mg/L)	Sulfate (mg/L)
Upper aquifer	SW3	9/25/98	13:45	106.0	0.2	ND	ND	83.0
	SW4	9/28/98	10:30	104.0	0.4	1.1	ND	53.0
	SW7	9/28/98	12:37	162.0	0.2	0.5	ND	48.1
	URS-2S	9/25/98	9:50	155.0	0.2	0.5	ND	163.0
	Azon 2	9/30/98	11:00	200.0	0.1	ND	ND	37.2
	Azon 6	9/30/98	9:22	207.0	0.1	0.3	ND	35.8
	URS-10S	9/30/98	12:15	197.0	0.1	0.8	ND	44.6
Lower aquifer	DW3	9/25/98	12:35	209.0	0.2	ND	ND	81.0
	DW4	9/28/98	9:15	207.0	0.1	ND	ND	81.1
	DPW	9/28/98	13:21	215.0	0.2	0.2	ND	65.8
	URS-2D	9/25/98	8:35	135.0	0.2	ND	ND	83.4
Single aquifer	URS-3D	9/22/98	10:30	195.0	0.2	0.8	ND	57.7
	Johnson City #2	9/22/98	9:00	115.0	0.2	0.6	ND	45.6

Table 1b, continued

Laboratory measurements - organic constituents

	Well or sample	Date	Time	Total organic carbon (mg/L)	Acetone (µg/L)	Benzene (µg/L)	Chloroethane (µg/L)	Chloroform (µg/L)	1,1-Dichloroethane (µg/L)	*cis*-1,2-Dichloroethene (µg/L)
Upper aquifer	SW3	9/25/98	13:45	1.1	ND	ND	ND	ND	0.1	0.3
	SW4	9/28/98	10:30	1.6	ND	ND	0.8	ND	9.1	9.1
	SW7	9/28/98	12:37	0.4	ND	ND	ND	ND	ND	ND
	URS-2S	9/25/98	9:50	0.4	ND	ND	ND	0.1	0.7	3.1
	Azon 2	9/30/98	11:00	0.8	ND	1.0	ND	ND	1.6	ND
	Azon 6	9/30/98	9:22	0.8	ND	ND	ND	ND	ND	ND
	URS-10S	9/30/98	12:15	0.5	ND	ND	ND	ND	0.7	1.4
Lower aquifer	DW3	9/25/98	12:35	0.2	21.0	ND	ND	ND	0.2	24.0
	DW4	9/28/98	9:15	ND	ND	ND	ND	ND	ND	ND
	DPW	9/28/98	13:21	ND	ND	ND	ND	ND	1.2	7.5
	URS-2D	9/25/98	8:35	ND	ND	ND	ND	ND	ND	8.5
Single aquifer	URS-3D	9/22/98	10:30	0.3	ND	ND	ND	0.1	0.5	1.7
	Johnson City #2	9/22/98	9:00	0.4	ND	ND	ND	ND	0.3	0.3

	Well or sample	Date	Time	1,1-Dichloroethene (µg/L)	Dibromo-chloromethane (µg/L)	1,2,-Dichloro-1,1,2-trifluorethane (µg/L)	1,4-Dioxane (µg/L)	Ethylbenzene (µg/L)	Isopropylbenzene (µg/L)
Upper aquifer	SW3	9/25/98	13:45	ND	ND	ND	ND	ND	ND
	SW4	9/28/98	10:30	0.3	ND	3.9	ND	ND	ND
	SW7	9/28/98	12:37	ND	ND	ND	ND	ND	ND
	URS-2S	9/25/98	9:50	ND	0.1	ND	ND	ND	ND
	Azon 2	9/30/98	11:00	ND	ND	ND	ND	1.2	0.2
	Azon 6	9/30/98	9:22	ND	ND	ND	ND	ND	ND
	URS-10S	9/30/98	12:15	ND	ND	ND	ND	ND	ND
Lower aquifer	DW3	9/25/98	12:35	ND	ND	ND	6.1	ND	ND
	DW4	9/28/98	9:15	ND	ND	ND	ND	ND	ND
	DPW	9/28/98	13:21	0.2	ND	ND	ND	ND	ND
	URS-3D	9/22/98	10:30	ND	ND	ND	ND	ND	ND
Single aquifer	Johnson City #2	9/22/98	9:00	ND	ND	ND	ND	ND	ND
	URS-2D	9/25/98	8:35	ND	ND	ND	6.5	ND	ND

Table 1b, continued

Laboratory measurements - organic constituents

	Well or sample	Date	Time	Methyl-t-butyl ether (µg/L)	2,2-Dimethylhexane (µg/L)	2,3-Dimethylhexane (µg/L)	1-Ethynyl-3-ethylbenzene (µg/L)	(1-Methylbutyl)-oxirane (µg/L)	Oxirane (µg/L)
Upper aquifer	SW3	9/25/98	13:45	ND	ND	ND	ND	ND	ND
	SW4	9/28/98	10:30	ND	ND	ND	ND	ND	ND
	SW7	9/28/98	12:37	ND	ND	ND	ND	ND	ND
	URS-2S	9/25/98	9:50	ND	ND	ND	ND	ND	ND
	Azon 2	9/30/98	11:00	0.7	5.3	2.5	1.1	3.5	1.4
	Azon 6	9/30/98	9:22	ND	ND	ND	ND	ND	ND
	URS-10S	9/30/98	12:15	ND	ND	ND	ND	2.5	ND
Lower aquifer	DW3	9/25/98	12:35	ND	ND	ND	ND	ND	ND
	DW4	9/28/98	9:15	ND	ND	ND	ND	ND	ND
	DPW	9/28/98	13:21	ND	ND	ND	ND	ND	ND
	URS-2D	9/25/98	8:35	ND	ND	ND	ND	ND	ND
Single aquifer	URS-3D	9/22/98	10:30	ND	ND	ND	ND	ND	ND
	Johnson City #2	9/22/98	9:00	ND	ND	ND	ND	ND	ND

	Well or sample	Date	Time	1-Methy-4-(1-methylethyl)-benzene (µg/L)	(2-Methy-1-propenyl)-benzene (µg/L)	1-Propylbenzene (µg/L)	Tetrachloroethene (µg/L)	1,2,3,4-Tetramethylbenzene (µg/L)	Total Xylenes (µg/L)
Upper aquifer	SW3	9/25/98	13:45	ND	ND	ND	ND	ND	ND
	SW4	9/28/98	10:30	ND	ND	ND	0.8	ND	ND
	SW7	9/28/98	12:37	ND	ND	ND	ND	ND	ND
	URS-2S	9/25/98	9:50	ND	ND	ND	ND	ND	0.4
	Azon 2	9/30/98	11:00	1.3	1.0	1.6	ND	1.1	1.1
	Azon 6	9/30/98	9:22	ND	ND	ND	ND	ND	ND
	URS-10S	9/30/98	12:15	ND	ND	ND	0.2	ND	ND
Lower aquifer	DW3	9/25/98	12:35	ND	ND	ND	ND	ND	ND
	DW4	9/28/98	9:15	ND	ND	ND	ND	ND	ND
	DPW	9/28/98	13:21	ND	ND	ND	ND	ND	ND
	URS-2D	9/25/98	8:35	ND	ND	ND	ND	ND	ND
Single aquifer	URS-3D	9/22/98	10:30	ND	ND	ND	ND	ND	ND
	Johnson City #2	9/22/98	9:00	ND	ND	ND	ND	ND	ND

Table 1b, continued

Laboratory measurements - organic constituents, continued

	Well or sample	Date	Time	1,1,1-Trichloroethane (µg/L)	Trichloroethene (µg/L)	Trichlorofluoromethane (µg/L)	1,1,2-Trichlorotrifluoroethane (µg/L)
Upper aquifer	SW3	9/25/98	13:45	0.4	1.3	ND	ND
	SW4	9/28/98	10:30	3.2	15.0	1.5	1.1
	SW7	9/28/98	12:37	ND	ND	ND	ND
	URS-2S	9/25/98	9:50	0.9	1.5	ND	ND
	Azon 2	9/30/98	11:00	0.5	1.5	ND	ND
	Azon 6	9/30/98	9:22	0.5	0.4	ND	ND
	URS-10S	9/30/98	12:15	2.9	3.7	ND	ND
Lower aquifer	DW3	9/25/98	12:35	ND	ND	ND	ND
	DW4	9/28/98	9:15	ND	ND	ND	ND
	DPW	9/28/98	13:21	0.6	2.6	ND	ND
	URS-2D	9/25/98	8:35	ND	ND	ND	ND
Single aquifer	URS-3D	9/22/98	10:30	3.4	2.0	ND	ND
	Johnson City #2	9/22/98	9:00	1.5	0.6	ND	ND

	Well or sample	Date	Time	1,2,4-Trimethylbenzene (µg/L)	2,3,3-Trimethylpentane (µg/L)	Vinyl chloride (µg/L)
Upper aquifer	SW3	9/25/98	13:45	ND	ND	ND
	SW4	9/28/98	10:30	ND	ND	0.6
	SW7	9/28/98	12:37	ND	ND	ND
	URS-2S	9/25/98	9:50	0.1	ND	ND
	Azon 2	9/30/98	11:00	1.3	2.6	ND
	Azon 6	9/30/98	9:22	ND	ND	ND
	URS-10S	9/30/98	12:15	ND	ND	ND
Lower aquifer	DW3	9/25/98	12:35	ND	ND	ND
	DW4	9/28/98	9:15	ND	ND	ND
	DPW	9/28/98	13:21	ND	ND	ND
	URS-2D	9/25/98	8:35	ND	ND	ND
Single aquifer	URS-3D	9/22/98	10:30	ND	ND	ND
	Johnson City #2	9/22/98	9:00	ND	ND	ND

Explanation: ND, not detected.

Table 2a. Chemical distinctions between upper and lower aquifers on and near U.S. Air Force Plant 59, May 4-7, 1998

[ND, not detected; mg/L, milligrams per liter, µg/L, micrograms per liter, µS/cm, pε, redox potential]

	Alkalinity (mg/L as $CaCO_3$)	Fe^{2+} (mg/L)	Mn (mg/L)	Nitrate (mg/L)	Dissolved oxygen (mg/L)	pε based on S^{2-}/S^{6+} couple	pε based on dissolved oxygen
Upper aquifer							
(wells SW3, SW4, SW7, URS-2S, Azon 2, Azon 6 & URS-10S)							
Range	242 to 336	0.0 to 0.2.6	ND to 0.6	ND to 2.6	0.0 to 5.8	-2.8 to -3.3	13.9 to 14.8
Average*	281	0.4	0.1	1.1	2.9	-3.0	14.4
Lower aquifer							
(wells DW3, DW4, DPW, & URS-2D)							
Range	308 to 326	0.2 to 2.6	0.6 to 0.7	ND	0.0 to 0.1	-3.2 to -3.4	13.6 to 14.0
Average*	312	0.9	0.7	ND	0.1	-3.3	13.8
Single aquifer							
(wells URS-3D & Johnson City #2)							
Range	212 to 296	0.0 to 0.1	ND to 0.0	1.0	1.2 to 10.3	-3.2	13.8 to 14.4
Average*	254	0.1	0.0	1.0	5.8	-3.2	14.1

	Trichloroethene (µg/L)	*cis*-1,2-Dichloroethene (µg/L)	1,1,1-Trichloroethane (µg/L)	1,1-Dichloroethane (µg/L)	Dissolved organic carbon (mg/L)
Upper aquifer					
(wells SW3, SW4, SW7, URS-2S, Azon 2, Azon 6 & URS-10S)					
Range	0.4 to 17.4	ND to 4.0	0.7 to 49.0	ND to 4.9	1.1 to 1.4
Average*	4.0	0.9	8.7	1.3	1.2
Lower aquifer					
(wells DW3, DW4, DPW, & URS-2D)					
Range	ND to 3.4	ND to 18.7	ND to 1.2	ND to 1.6	ND
Average*	0.9	8.0	0.3	0.4	ND
Single aquifer					
(wells URS-3D & Johnson City #2)					
Range	ND to 0.6	ND to 0.1	ND to 2.9	ND to 0.5	ND
Average*	0.3	0.1	1.5	0.3	ND

Explanation: ND, not detected. *ND counted as 0.0 for computing averages (except for pε values).

Table 2b. Chemical distinctions between upper and lower aquifers on and near U.S. Air Force Plant 59, September 22-30, 1998

[ND, not detected; mg/L, milligrams per liter, µg/L, micrograms per liter, µS/cm, pε, redox potential]

	Alkalinity (mg/L as $CaCO_3$)	Fe^{2+} (mg/L)	Mn (mg/L)	Nitrate (mg/L)	Dissolved oxygen (mg/L)	pe based on S^{2-}/S^{6+} couple	pe based on dissolved oxygen
Upper aquifer							
(wells SW3, SW4, SW7, URS-2S, Azon 2, Azon 6 & URS-10S)							
Range	208 to 358	0.0 to 0.9	ND to 0.4	ND to 1.1	0.0 to 4.5	-2.8 to -3.2	13.8 to 14.4
Average*	292	0.1	0.1	0.6	1.6	-3.0	14.2
Lower aquifer							
(wells DW3, DW4, DPW, & URS-2D)							
Range	289 to 316	0.4 to 4.1	0.7 to 0.8	ND to 0.2	0.0 to 0.2	-2.8 to -3.5	13.9 to 14.3
Average*	308	1.5	0.7	0.1	0.1	-3.1	14.1
Single aquifer							
(wells URS-3D & Johnson City #2)							
Range	210 to 306	0.0	ND to 0.0	0.6 to 0.8	>0.8	--	14.4 to 14.6
Average*	258	0.0	0.0	0.7	>0.8	--	14.5

	Trichloroethene (µg/L)	*cis*-1,2-Dichloroethene (µg/L)	1,1,1-Trichloroethane (µg/L)	1,1-Dichloroethane (µg/L)	Dissolved organic carbon (mg/L)
Upper aquifer					
(wells SW3, SW4, SW7, URS-2S, Azon 2, Azon 6 & URS-10S)					
Range	ND to 15.0	ND to 9.1	ND to 3.2	ND to 9.1	0.4 to 1.6
Average*	3.3	2.0	1.2	2.0	0.8
Lower aquifer					
(wells DW3, DW4, DPW, & URS-2D)					
Range	ND to 2.6	ND to 24.0	ND to 0.6	ND to 1.2	ND to 0.2
Average*	0.7	10.0	0.2	0.4	0.1
Single aquifer					
(wells URS-3D & Johnson City #2)					
Range	0.6 to 2.0	0.3 to 1.7	1.5 to 3.4	0.3 to 0.5	0.3 to 0.4
Average*	1.3	1.0	2.5	0.4	0.4

Table 3. Summary of chlorinated hydrocarbon concentrations in ground water around U.S. Air Force Plant 59, Johnson City, NY, 1991-1998

[NA, not analyzed, µg/L, micrograms per liter]

Trichloroethene (µg/L)

	November-91	August-94	December-94	December-95	April-97	July-97	May-98	September-98
Upper aquifer wells on and immediately west of USAF Plant 59								
SW3	9.0	NA	1.2	3.0	NA	1.0	0.4	1.3
SW4	95.0	NA	370.0	800.0	54.0	290.0	17.4	15.0
SW7	NA	NA	16.5	NA	NA	4.0	2.5	ND
URS-2S	NA	1.4	NA	NA	NA	2.0	0.6	1.5
Upper aquifer wells near Azon Road								
Azon 6	NA	ND	NA	NA	NA	9.0	3.8	0.4
URS-10S	NA	1.3	NA	NA	NA	2.0	1.8	3.7
Lower aquifer wells on and immediately west of USAF Plant 59								
DW3	ND	NA	ND	ND	ND	ND	ND	ND
DW4	NA	NA	1.2	NA	NA	ND	ND	ND
DPW	NA	NA	4.0	NA	NA	4.0	3.4	2.6
URS-2D	NA	ND	NA	NA	NA	ND	ND	ND
Lower aquifer well near Azon Road								
Azon 2	NA	NA	NA	NA	NA	3.0	1.4	1.5
Wells in single aquifer near Susquehanna River								
URS-3D	NA	1.2	NA	NA	NA	2.0	0.6	2.0
JC #2	NA	ND	NA	NA	NA	NA	ND	0.6

***cis*-1,2-Dichloroethene (µg/L)**

	November-91	August-94	December-94	December-95	April-97	July-97	May-98	September-98
Upper aquifer wells on and immediately west of USAF Plant 59								
SW3	ND	NA	ND	ND	NA	ND	0.1	0.3
SW4	ND	NA	19.0	28.0	7.0	15.0	4.0	9.1
SW7	NA	NA	110.0	NA	NA	2.0	0.8	ND
URS-2S	NA	7.2	NA	NA	NA	1.0	1.2	3.1
Upper aquifer wells near Azon Road								
Azon 6	NA	ND	NA	NA	NA	ND	ND	ND
URS-10S	NA	ND	NA	NA	NA	1.0	ND	1.4
Lower aquifer wells on and immediately west of USAF Plant 59								
DW3	ND	ND	40.0	ND	ND	ND	18.7	24.0
DW4	NA	NA	0.3	NA	NA	ND	ND	ND
DPW	NA	NA	13.0	NA	NA	11.0	10.7	7.5
URS-2D	NA	3.7	NA	NA	NA	42.0	2.6	8.5
Lower aquifer well near Azon Road								
Azon 2	NA	NA	NA	NA	NA	ND	ND	ND
Wells in single aquifer near Susquehanna River								
URS-3D	NA	1.4	NA	NA	NA	2.0	0.1	1.7
JC #2	NA	ND	NA	NA	NA	NA	2.6	0.3

Table 3, continued

1,1,1-Trichloroethane (µg/L)

[NA, not analyzed, µg/L, micrograms per liter]

	November-91	August-94	December-94	December-95	April-97	July-97	May-98	September-98
Upper aquifer wells on and immediately west of USAF Plant 59								
SW3	12.0	NA	ND	ND	ND	ND	0.7	0.4
SW4	2.0	NA	20.0	ND	ND	ND	3.7	3.2
SW7	1.0	NA	4.6	NA	NA	ND	1.6	ND
URS-2S	NA	2.7	NA	NA	NA	2.0	0.9	0.9
Upper aquifer wells near Azon Road								
Azon 2	NA	NA	NA	NA	NA	9.0	3.0	0.5
Azon 6	NA	150.0	NA	NA	NA	180.0	49.0	0.5
URS-10S	NA	30.0	NA	NA	NA	13.0	2.2	2.9
Lower aquifer wells on and immediately west of USAF Plant 59								
DW3	ND	NA	ND	ND	ND	ND	ND	ND
DW4	NA	NA	ND	NA	NA	ND	ND	ND
DPW	NA	NA	1.2	NA	NA	1.0	1.2	0.6
URS-2D	NA	ND	NA	NA	NA	ND	ND	ND
Wells in single aquifer near Susquehanna River								
URS-3D	NA	3.0	NA	NA	NA	5.0	2.9	3.4
JC #2	NA	5.5	NA	NA	NA	NA	ND	1.5

1,1-Dichloroethane (µg/L)

	November-91	August-94	December-94	December-95	April-97	July-97	May-98	September-98
Upper aquifer wells on and immediately west of USAF Plant 59								
SW3	5.0	NA	ND	ND	NA	ND	0.7	0.1
SW4	ND	NA	8.5	7.0	7.0	ND	2.4	9.1
SW7	NA	NA	30.0	NA	NA	ND	ND	ND
URS-2S	NA	1.4	NA	NA	NA	ND	0.4	0.7
Upper aquifer wells near Azon Road								
Azon 2	NA	NA	NA	NA	NA	8.0	4.9	1.6
Azon 6	NA	ND	NA	NA	NA	ND	ND	ND
URS-10S	NA	1.6	NA	NA	NA	ND	0.8	0.7
Lower aquifer wells on and immediately west of USAF Plant 59								
DW3	ND	NA	ND	ND	ND	ND	ND	0.2
DW4	NA	NA	ND	NA	NA	ND	ND	ND
DPW	NA	NA	2.4	NA	NA	2.0	1.6	1.2
URS-2D	NA	ND	NA	NA	NA	ND	ND	ND
Wells in single aquifer near Susquehanna River								
URS-3D	NA	ND	NA	NA	NA	ND	0.5	0.5
JC #2	NA	ND	NA	NA	NA	NA	ND	0.3

Explanation: NA, not analyzed; ND, not detected

Table 4. Analytical protocols for sampling of USAF Plant 59, Johnson City, NY, May 4-7, 1998

[mg/L, milligrams per liter, µg/L, micrograms per liter]

Purgeable Organic Compounds	Reporting limits (µg/L)	Holding times (days)	Analysis date	Metals	Reporting limits (mg/L)	Holding time (days)	Analysis date	Anions and organic carbon	Reporting limits (mg/L)	Holding times (days)	Analysis dates
Benzene	1.0	14	5/15	Aluminum	0.10	28	6/13	Chloride	15.0	28	5/9 - 5/29
n-Butylbenzene	1.0	14	5/15	Barium	0.01	28	6/13	Fluoride	1.0	28	5/7 - 5/9
sec-Butylbenzene	1.0	14	5/15	Boron	0.10	28	6/13	Nitrate-N	0.50	2	5/7 - 5/9
Chloroethane	1.0	14	5/15	Calcium	0.20	28	6/13	Orthophosphate-P	0.50	2	5/7 - 5/9
1,1-Dichloroethane	1.0	14	5/15	Chromium	0.01	28	6/13	Sulfate	5.0	28	5/9 - 5/29
cis-1,2-Dichloroethene	1.0	14	5/15	Total iron	0.10	28	6/13	Ammonia-N	0.10	28	5/14 - 5/29
1,1-Dichloroethene	1.0	14	5/15	Potassium	5.0	28	6/13	Total Kjeldahl-N	0.50	28	6/1 - 6/4
Ethylbenzene	1.0	14	5/15	Magnesium	0.20	28	6/13	Total organic carbon	1.0	28	6/1
Isopropylbenzene	1.0	14	5/15	Manganese	0.10	28	6/13				
Naphthalene	1.0	14	5/15	Sodium	5.0	28	6/13				
n-Propylbenzene	1.0	14	5/15	Nickel	0.04	28	6/13				
Tetrachloroethene	1.0	14	5/15	Silica	0.50	28	6/13				
Toluene	1.0	14	5/15	Antimony	0.06	28	6/13				
1,1,1-Trichloroethane	1.0	14	5/15	Selenium	0.20	28	6/13				
Trichloroethene	1.0	14	5/15	Tin	0.10	28	6/13				
Trichlorofluoromethane	1.0	14	5/15								
1,2,4-Trimethylbenzene	1.0	14	5/15								
Vinyl chloride	1.0	14	5/15								
Total Xylenes	1.0	14	5/15								

Table 4b. Analytical protocols for sampling of USAF Plant 59, Johnson City, NY, September 22-30, 1998

[mg/L, milligrams per liter, µg/L, micrograms per liter]

Purgeable Organic Compounds	Reporting limits (µg/L)	Holding times (days)	Analysis date	Metals	Reporting limits (mg/L)	Holding time (days)	Analysis date	Anions and organic carbon	Reporting limits (mg/L)	Holding times (days)	Analysis dates
Acetone	0.2	8 - 14	9/30 - 10/12	Calcium	0.2	15 - 43	10/15 - 11/13	Chloride	15.0	1 - 2	9/23 - 10/1
Benzene	0.5	8 - 14	9/30 - 10/12	Total iron	0.1	15 - 43	10/15 - 11/13	Fluoride	1.0	1 - 18	9/23 - 10/18
Chloroethane	0.5	8 - 14	9/30 - 10/12	Magnesium	0.2	15 - 43	10/15 - 11/13	Nitrate-N	0.5	1 - 2	9/23 - 10/1
Chloroform	0.1	8 - 14	9/30 - 10/12	Manganese	0.01	15 - 43	10/15 - 11/13	Orthophosphate-P	0.5	1 - 2	9/23 - 10/1
1,1-Dichloroethane	0.1	8 - 14	9/30 - 10/12	Sodium	5.0	15 - 43	10/15 - 11/13	Sulfate	5.0	1 - 2	9/23 - 10/1
cis-1,2-Dichloroethene	0.1	8 - 14	9/30 - 10/12	Silica	0.5	15 - 43	10/15 - 11/13	Total organic carbon	1.0	6 - 8	10/1 - 10/6
1,1-Dichloroethene	0.1	8 - 14	9/30 - 10/12								
Dibromochloromethane	0.1	8 - 14	9/30 - 10/12								
1,2,-Dichloro-1,1,2 trifluorethane	0.1	8 - 14	9/30 - 10/12								
1,4-Dioxane	0.1	8 - 14	9/30 - 10/12								
Ethylbenzene	0.1	8 - 14	9/30 - 10/12								
Isopropylbenzene	0.1	8 - 14	9/30 - 10/12								
Methyl-t-butyl ether	0.5	8 - 14	9/30 - 10/12								
2,2-Dimethylhexane	0.1	8 - 14	9/30 - 10/12								
2,3-Dimethylhexane	0.1	8 - 14	9/30 - 10/12								
1-Ethynyl-3-ethylbenzene	0.1	8 - 14	9/30 - 10/12								
(1-Methylbutyl)-oxirane	0.1	8 - 14	9/30 - 10/12								
(3-Methylbutyl)-oxirane	0.1	8 - 14	9/30 - 10/12								
1-Methy-4-(1-methylethyl)-benzene	0.1	8 - 14	9/30 - 10/12								
(2-Methy-1-propenyl)-benzene	0.1	8 - 14	9/30 - 10/12								
1-Propylbenzene	0.1	8 - 14	9/30 - 10/12								
Tetrachloroethene	0.1	8 - 14	9/30 - 10/12								
1,2,3,4-Tetramethylbenzene	0.1	8 - 14	9/30 - 10/12								
Total Xylenes	0.2	8 - 14	9/30 - 10/12								
1,1,1-Trichloroethane	0.1	8 - 14	9/30 - 10/12								
Trichloroethene	0.1	8 - 14	9/30 - 10/12								
Trichlorofluoromethane	0.5	8 - 14	9/30 - 10/12								
1,1,2-Trichlorotrifluoroethane	0.1	8 - 14	9/30 - 10/12								
1,2,4-Trimethylbenzene	0.1	8 - 14	9/30 - 10/12								
2,3,3-Trimethylpentane	0.2	8 - 14	9/30 - 10/12								
Vinyl chloride	0.2	8 - 14	9/30 - 10/12								

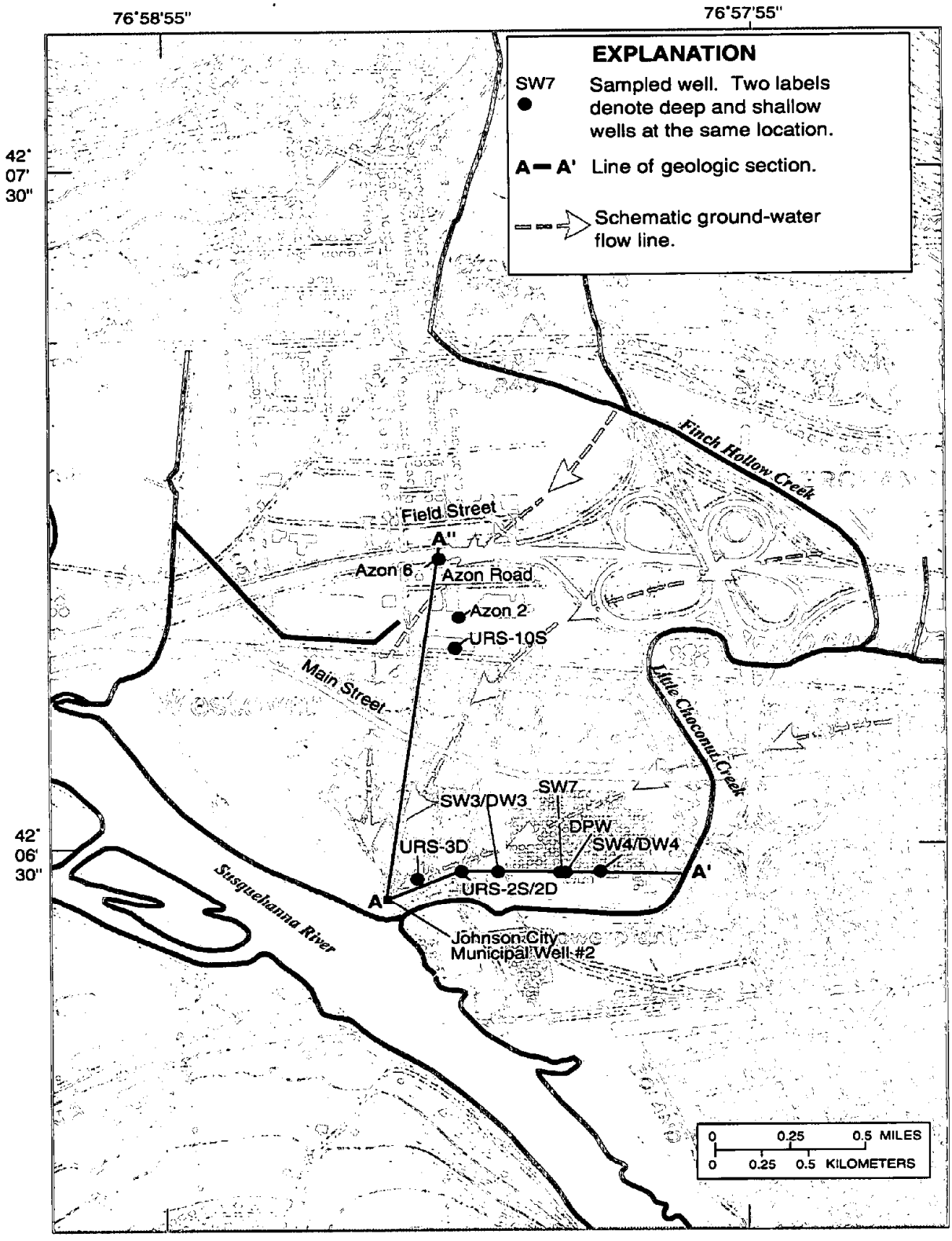

Figure 1. Study area, well locations, and cross-section locations near Johnson City, New York.

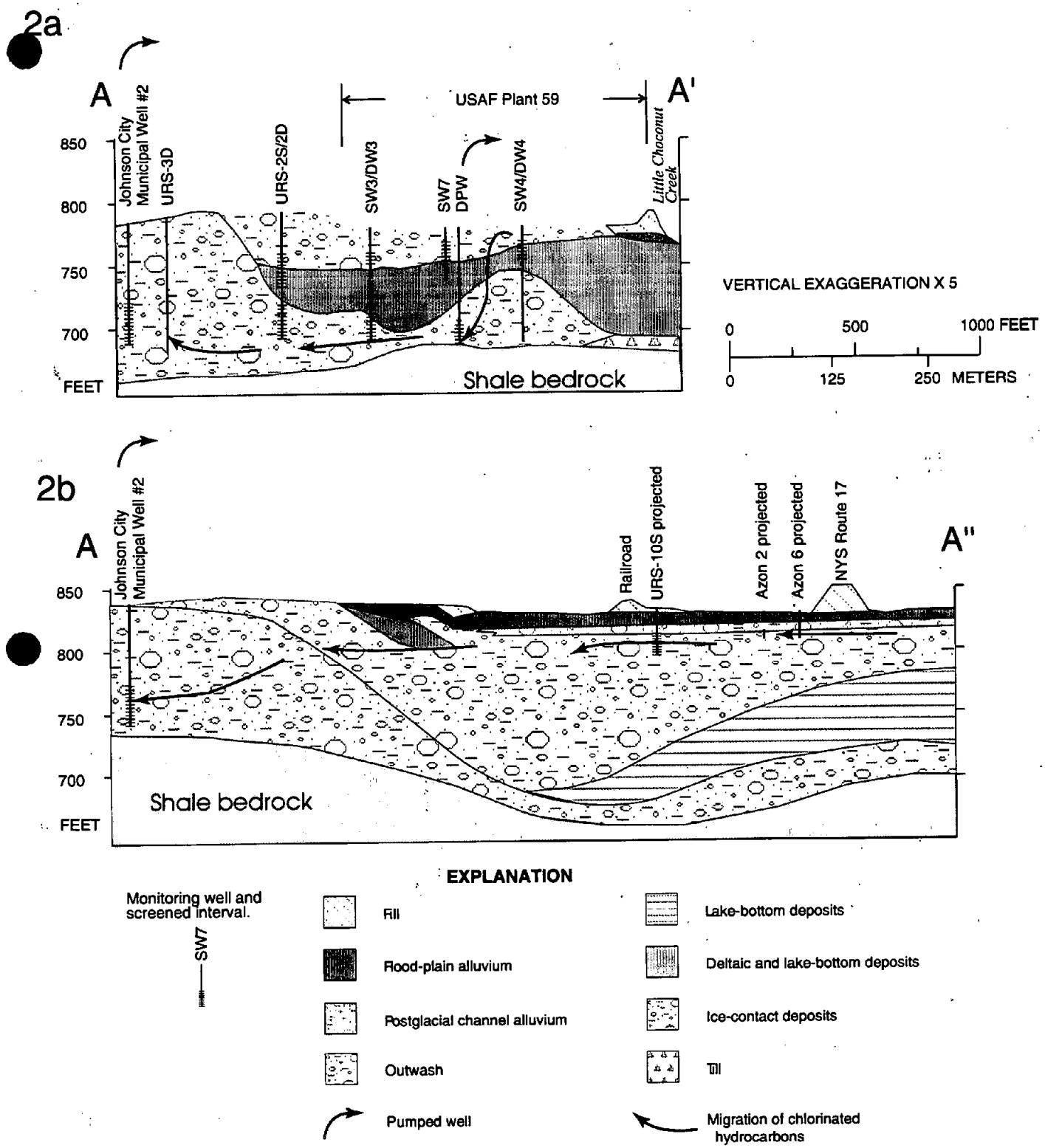

Figure 2. Geologic sections extending from Johnson City Municipal Well #2 east across U.S. Air Force Plant 59 (A-A', Figure 2a), and north to the Azon Road area (A-A", Figure 2b). Section lines shown in Figure 1.

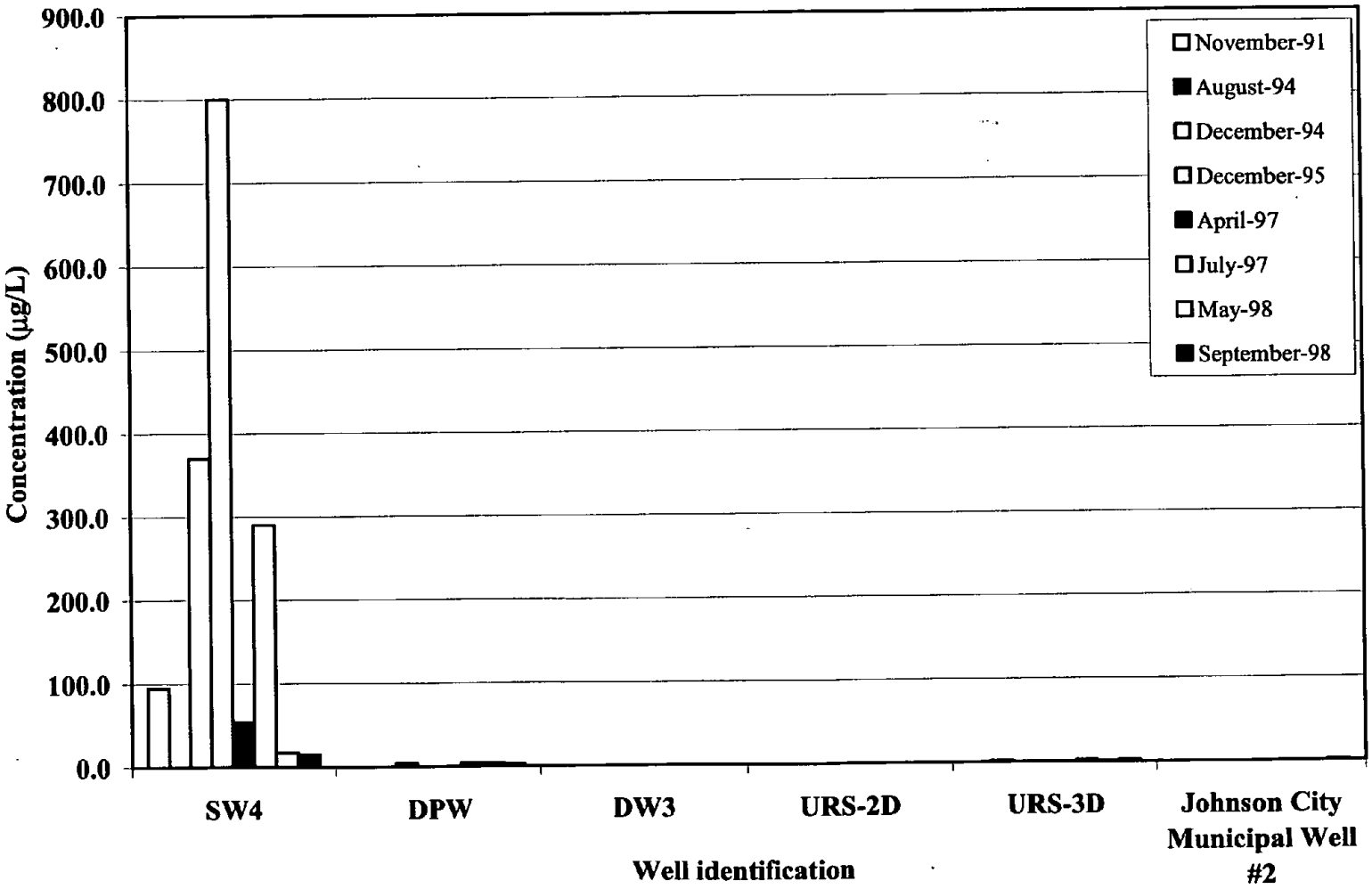
Trichloroethene concentations along flowpath across USAF Plant 59
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
Concentration (µg/L)
November-91
August-94
December-94
December-95
April-97
July-97
May-98
September-98
SW4
DPW
DW3
URS-2D
URS-3D
Johnson City Municipal Well #2
Well identification

Figure 3a

cis -1,2-dichloroethene concentrations along flowpath across USAF Plant 59

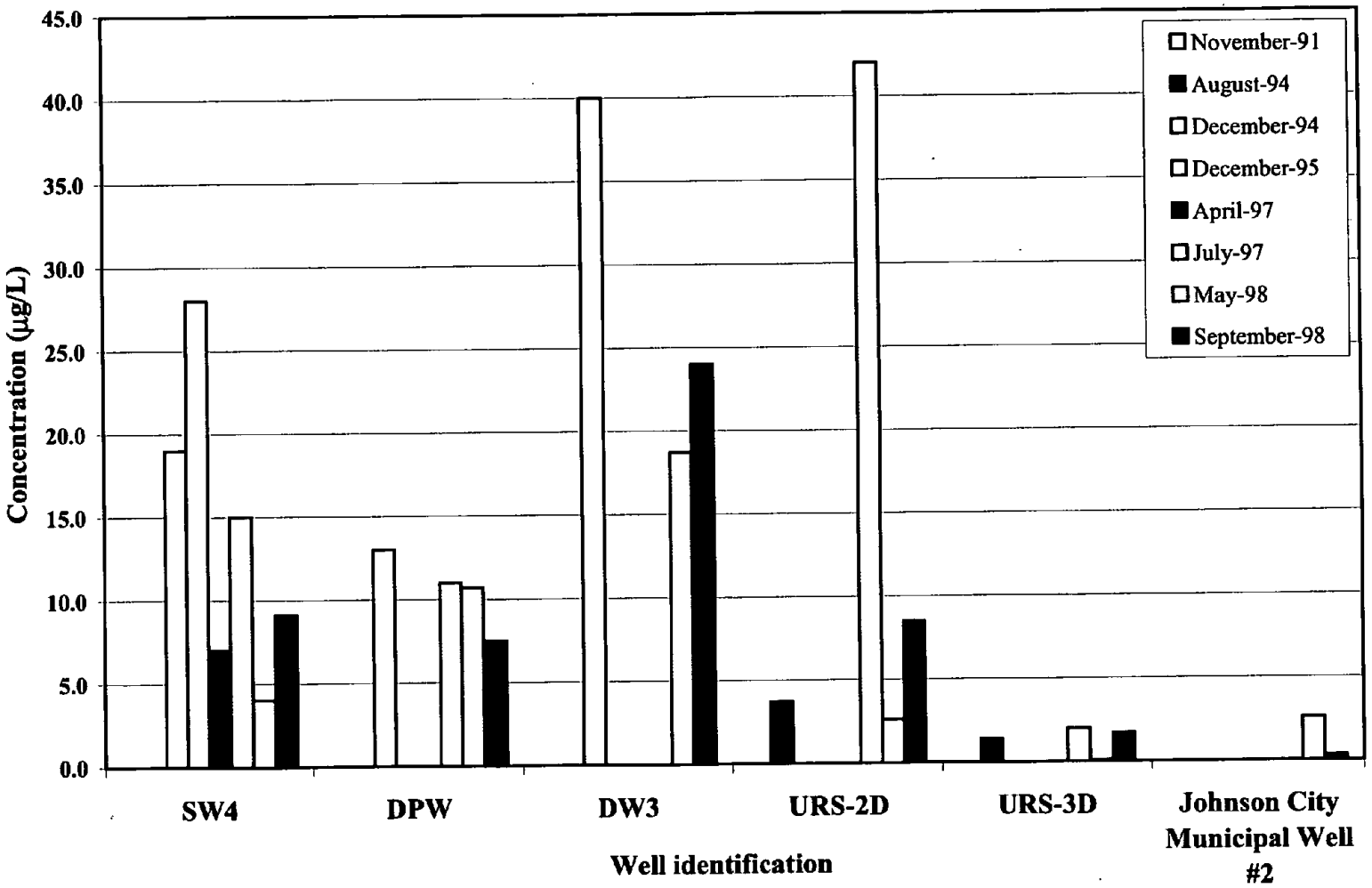

Figure 3b

1,1,1-trichloroethane concentrations along flowpath from Azon Road

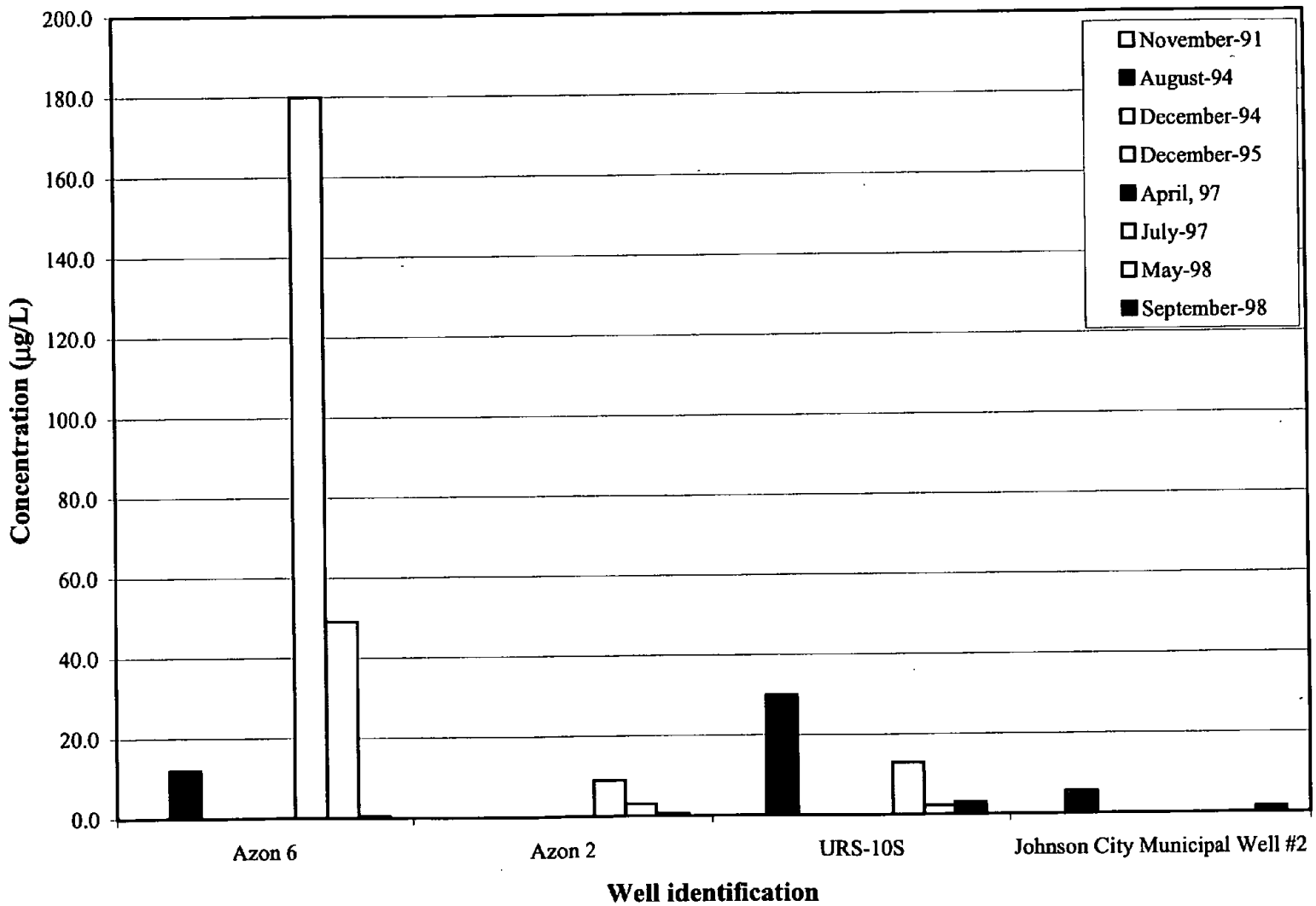

Figure 3c

1,1-dichloroethane concentrations along flowpath from Azon Road

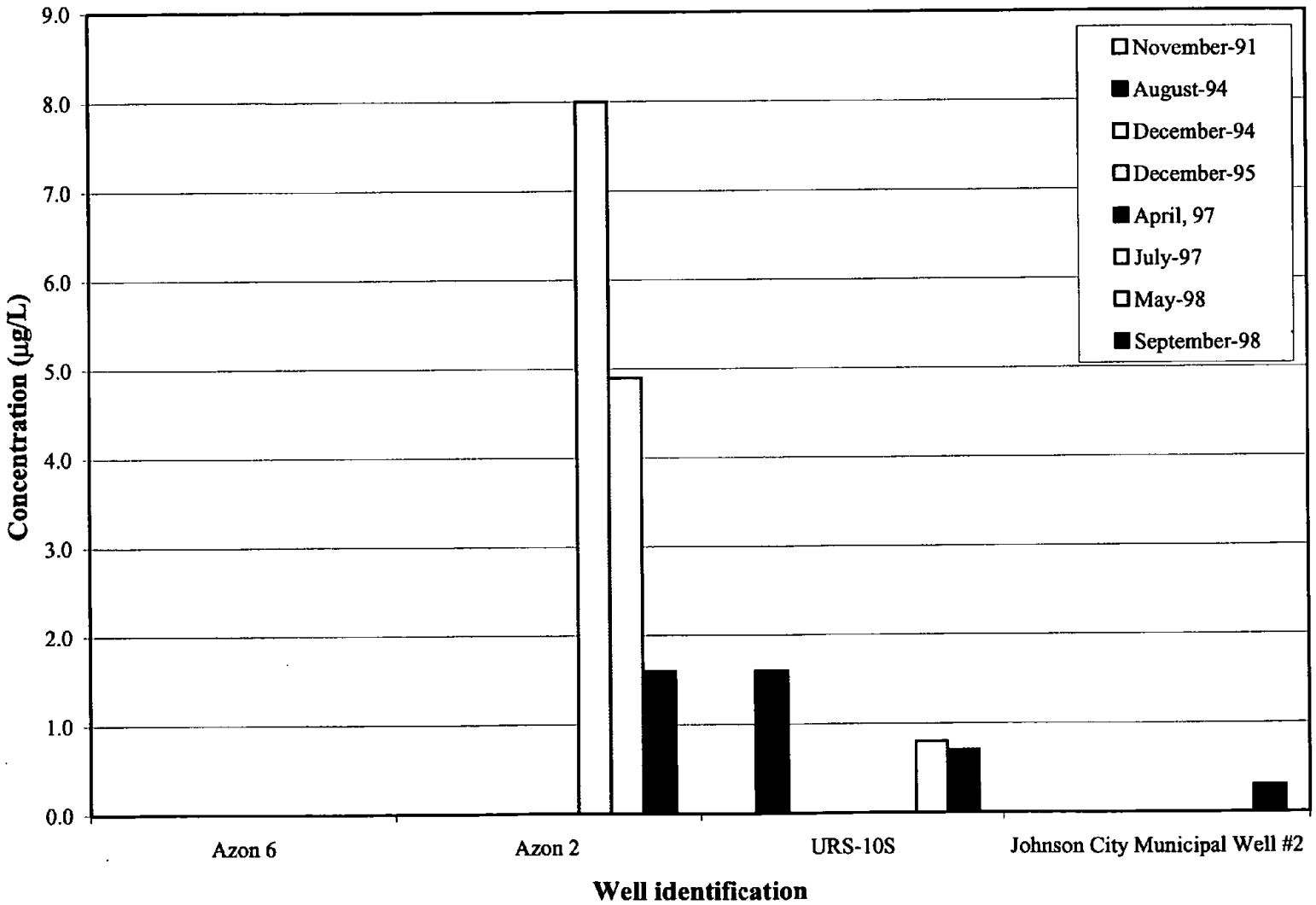

Figure 3d