Groundwater Contamination from Underground Solvent Storage Tanks Santa Clara Valley, CA

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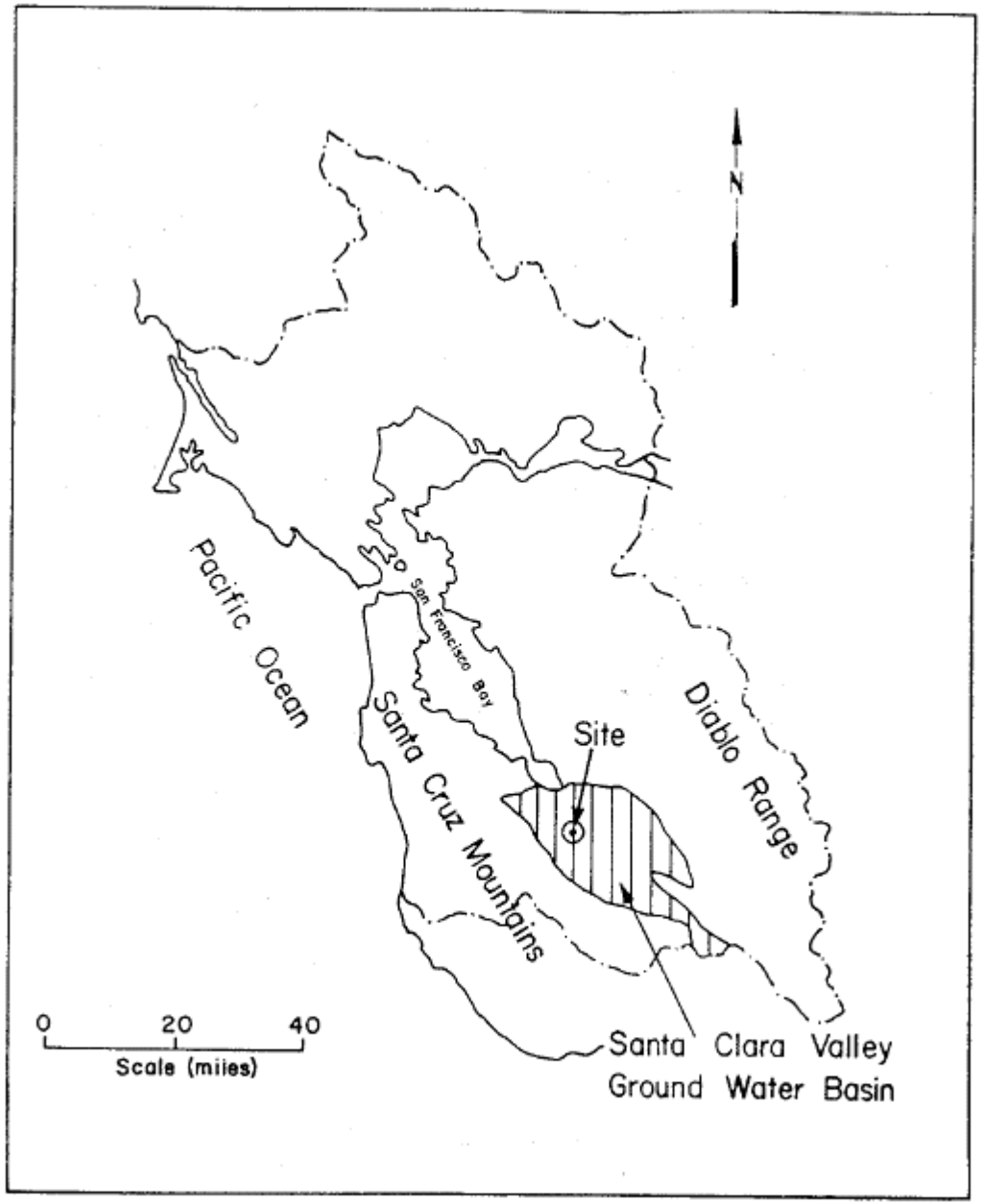
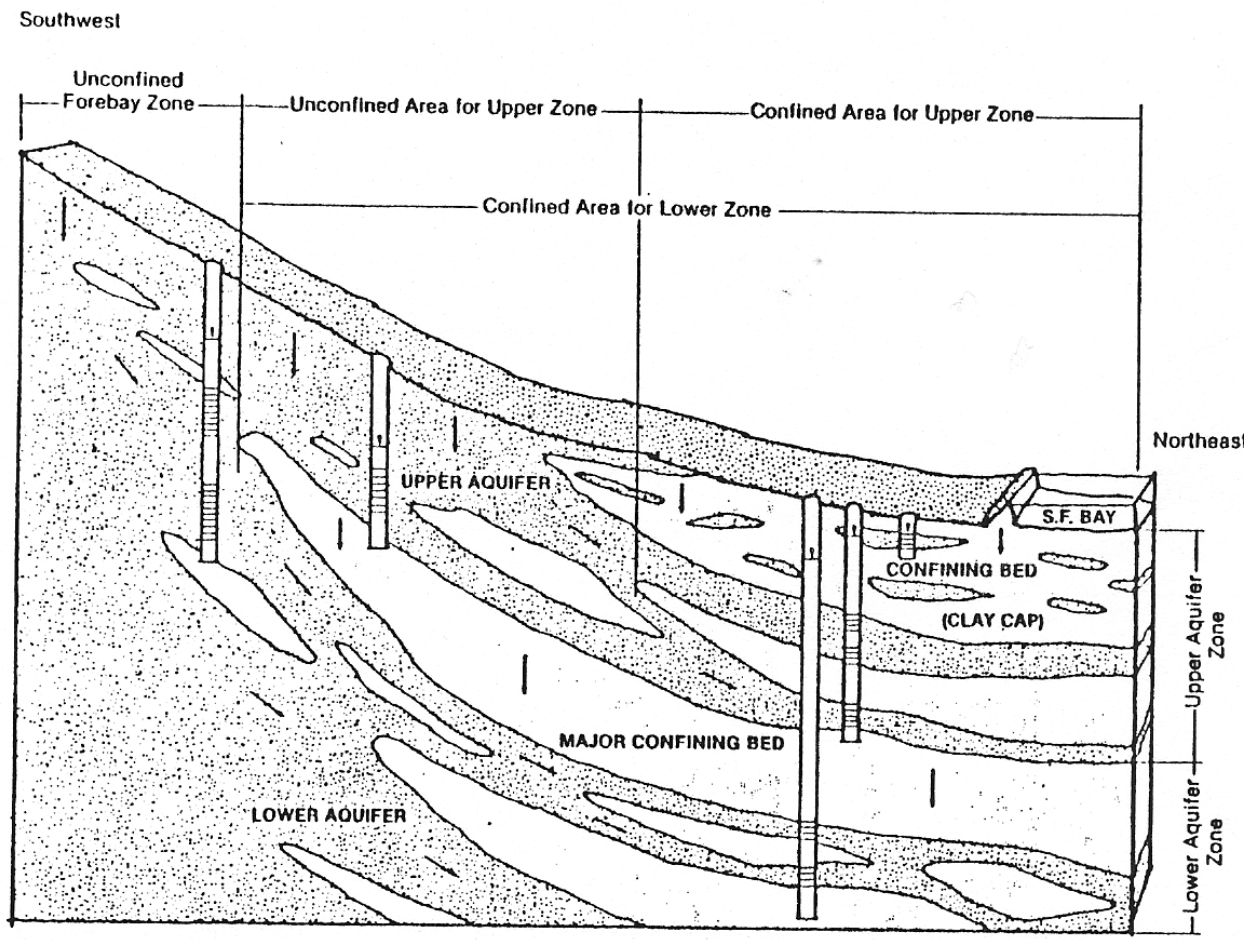


Figure 1: Location Map

SCHEMATIC CROSS SECTION FOR SANTA CLARA SUB-BASIN



Note: Arrows indicate direction of groundwater movement without regard to quantity.

From Back et al., The Geology of North America, Volume O-2, GSA, 1988

Site Plan

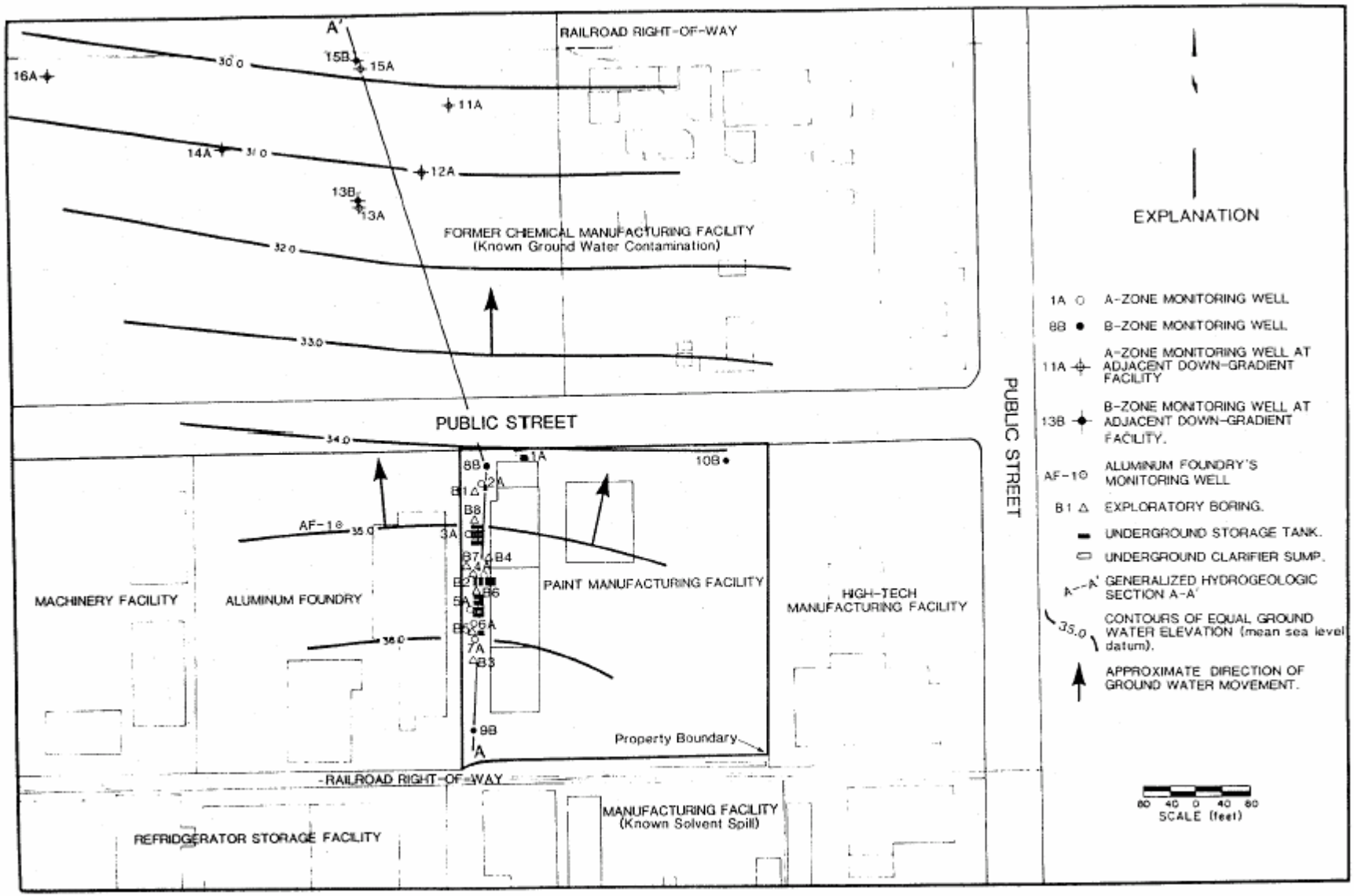


Figure 2: Plan of Study Area

Site History

- First tanks installed in 1956
- By 1983 there were 13 tanks with a capacity of 15,000 liters (4000 gallons) each for solvents and one smaller 2000 liters (550 gallons) tank for gasoline
- Contamination in groundwater was detected in 1983

TABLE 2

CHEMICALS DETECTED IN WATER SAMPLES FROM MONITORING WELLS AT THE SITE[1,2,3]

Concentration in mg/L (ppm)

Chemical Compound	1A	2A	3A	4A	5A	6A	7A	8B	9B	10B
Toluene	1.2	12.0	1.65	240	6.8	1.9	1.0	13.0	ND	ND
Xylene	6.7	24.0	46.0	38.0	23.0	6.9	15.0	11.0	ND	ND
Ethyl Benzene	3.9	7.0	16.0	9.7	4.5	1.4	0.4	2.2	ND	ND
Benzene	0.1	ND	ND	0.24	ND	ND	ND	5.8	ND	ND
Naphtalene	0.005	0.03	0.02	0.01	0.02	0.004	0.004	0.06	ND	ND
Phenol	0.004	0.02	ND	ND	ND	ND	ND	0.04	ND	ND
2,4-Dimethyl Phenol	0.02	0.03	0.02	0.03	ND	ND	ND	ND	ND	ND
Methyl Cyclohexane	0.1	5.0	50.0	2.0	10.0	3.0	2.0	ND	ND	ND
Cyclohexane	ND	ND	2.0	ND	0.5	0.2	0.3	ND	ND	ND
Propyl Benzene	0.08	0.1	0.2	0.6	0.4	ND	ND	ND	ND	ND
Trimethyl Benzene	0.3	0.4	0.5	3.0	3.0	ND	0.2	0.6	ND	ND
Tetrahydro Naphthalene	0.02	0.02	0.04	ND	0.04	ND	ND	ND	ND	ND
2-Butanone	ND	ND	ND	1.0	ND	ND	ND	ND	ND	ND
Methyl Isobutyl Ketone	ND	1.0	ND	6.0	ND	ND	ND	ND	ND	ND
Methylene Chloride	ND	ND	ND	1.2	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	ND	0.3	ND	ND	ND	ND	0.002	ND
1,1,1-Trichlorethane	ND	ND	ND	0.1	0.2	ND	ND	ND	ND	ND
1,1-Dichloroethane	ND	ND	ND	0.02	ND	ND	ND	ND	ND	ND
Penanthrene	ND	ND	ND	0.001	ND	ND	ND	ND	ND	ND
Cresol	ND	ND	ND	ND	ND	ND	ND	0.04	ND	ND
Methyl Napthalene	ND	ND	ND	ND	ND	ND	ND	0.03	ND	ND

NOTES:
1.ND = Not detected within laboratory detection limits.
2.Analyzed by U.S. EPA Test Method 624 and 625.
3.Samples taken at ground water surface with Teflon bailer.

Principal contaminants
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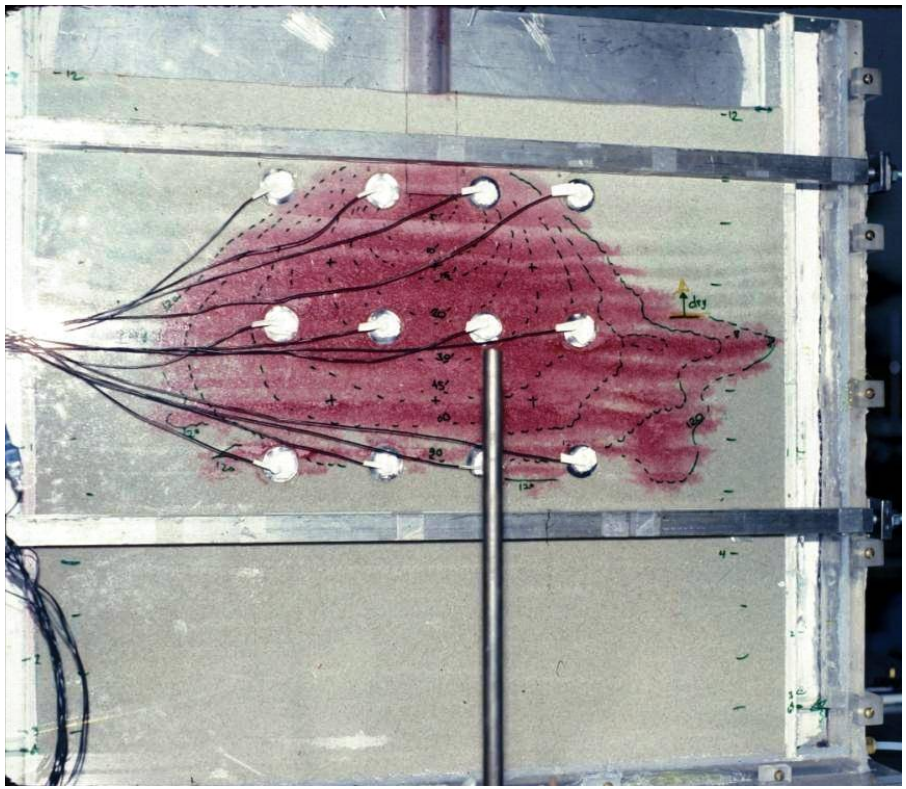
Non-Aqueous Phase Liquids (NAPLs)

- Toluene: S.G.= 0.87, Solubility 500 ppm, B.P.= 111°C
- Xylene: S.G.= 0.86-0.88, Solubility 135-198 ppm, B.P.= 138°-144°C
- Ethyl Benzene: S.G.= 0.87, Solubility 152 ppm, B.P.= 136° C
- Benzene: S.G.= 0.88, Solubility 1780 ppm, B.P.= 80° C

What we expected: LNAPL above the water table



Experimental data from Pantazidou (1993)


CME
CAUTION
CME

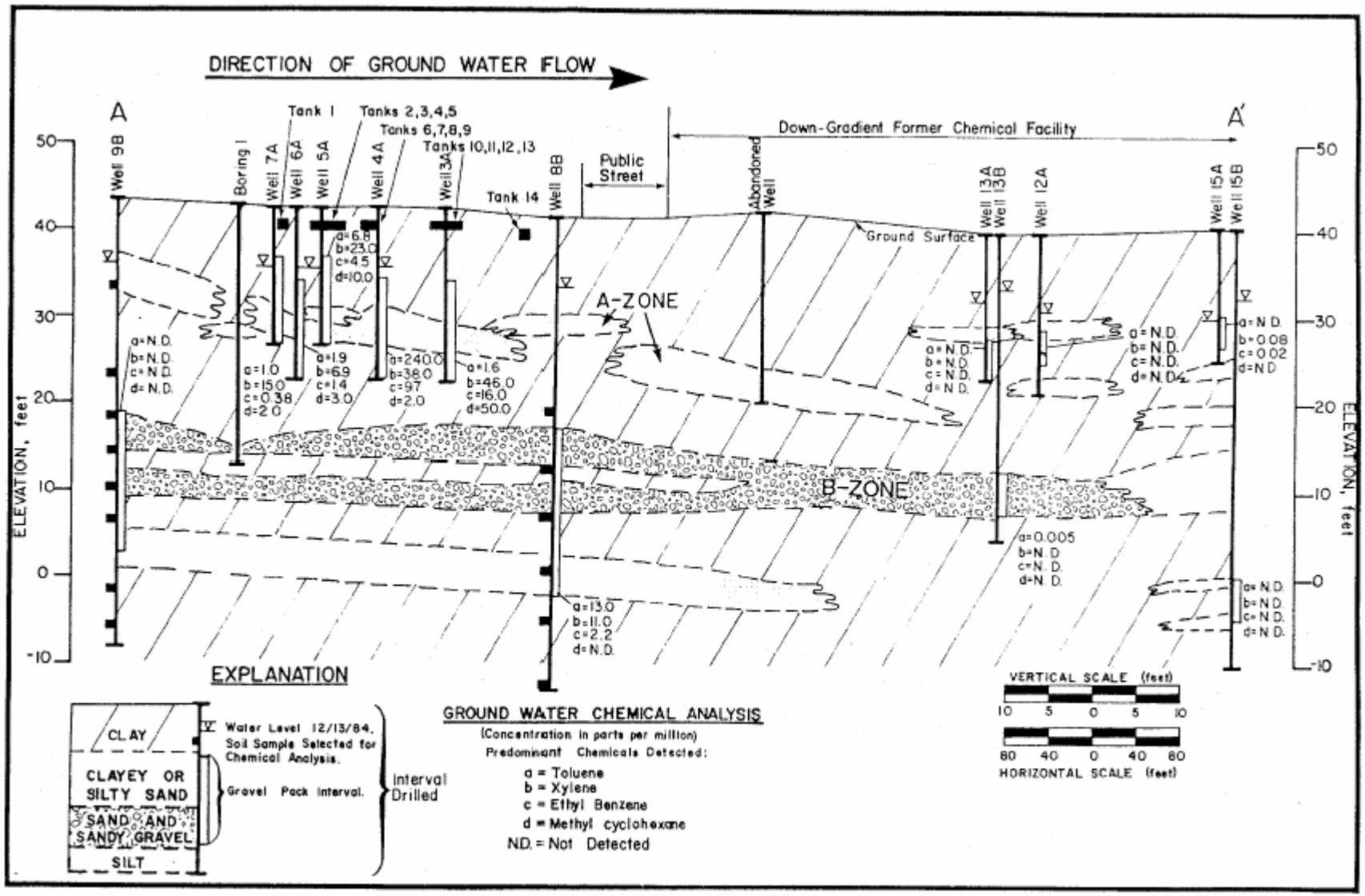


Figure 3: Generalized Hydrogeologic Section A-A'

TABLE 3

COMPARISON OF SOIL AND GROUND WATER SAMPLES TAKEN AT DIFFERENT DEPTHS[1,2,3]

(Concentrations in mg/kg, ppm)

WELL NO. 1A

	SOIL SAMPLES[2]		WATER SAMPLES[3]	
	9½ ft	15½ ft	Top[4]	Bottom[5]
Toluene	ND	4.4	1.2	2.7
Xylene	ND	14	6.7	4.9
Ethyl Benzene	ND	14	3.9	3.4
Propyl Benzene	ND	2.0	0.08	0.05
Trimethyl Benzene	ND	10	0.3	0.2

WELL NO. 5A

	SOIL SAMPLES		WATER SAMPLES	
	9 ft	15½ ft	Top	Bottom
Toluene	ND	0.1	6.8	4.9
Xylene	0.8	210	23	13
Ethyl Benzene	0.3	120	4.5	1.4
Propyl Benzene	ND	2.0	0.4	ND
Trimethyl Benzene	ND	4.0	3.0	0.3

WELL NO. 7A

	SOIL SAMPLES		WATER SAMPLES	
	8½ ft	15½ ft	Top	Bottom
Toluene	ND	0.1	1.0	ND
Xylene	0.5	1.2	15	8.7
Ethyl Benzene	0.1	0.5	0.4	ND
Propyl Benzene	ND	ND	ND	ND
Trimethyl Benzene	ND	ND	0.2	0.4

NOTES:
1. ND = Not detected within laboratory detection limits.
2. Soil samples analyzed by U.S. EPA Test Methods 8240 and 8270.
3. Ground water samples analyzed by U.S. EPA Test Methods 624 and 625.
4. Top - Samples obtained at ground water surface with Teflon bailer.
5. Bottom - Samples obtained near the bottom of the water column with submersible bladder pump.

TABLE 4

PREDOMINANT CHEMICALS DETECTED IN BORINGS B2, B4, B6, AND B8

Concentrations in mg/kg (ppm)

BORING B2

	Sample Depth, Feet												
Chemical Compound	3	5	7	9	11	13	15	17	19	21	23	26½	31½
Toluene	22	8.3	63	350	63	ND	15	ND	490	65	ND	65	110
Xylene	61	22	82	81	190	13	35	13	580	43	4	13	1
Ethyl Benzene	15	5.4	20	46	110	8.7	8.6	8.5	130	11	1.3	4.6	ND
Benzene	0.04	ND	0.1	0.9	0.3	ND	2.1	ND	41	2.9	0.7	0.7	0.6
Methyl Cyclohexane	1.6	0.7	7.3	53	17	NA	NA	NA	NA	NA	NA	NA	NA
Total Hydrocarbons	99.64	36.4	172.4	530.9	380.3	21.7	60.7	21.5	1241	121.9	6.0	83.3	111.6

BORING B4

	Sample Depth, Feet							
Chemical Compound	9	14	19	24	29	34	39	44
Toluene	57	1.4	56	12	71	0.3	0.4	0.3
Xylene	77	18	100	19	500	1.5	0.7	5.9
Ethyl Benzene	16	4.8	20	5.2	52	0.2	0.1	1.3
Benzene	ND	ND	0.6	0.4	2.1	0.02	ND	0.06
Methyl Cyclohexane	NA	NA	NA	NA	NA	ND	0.03	0.3
Total Hydrocarbons	150	24.2	176.6	36.8	625.1	2.02	1.33	7.86

BORING B6

	Sample Depth, Feet						
Chemical Compound	6	11	16	21	26	31	36
Toluene	1200	230	17	290	65	29	1.8
Xylene	1100	640	8.0	130	26	9.8	0.7
Ethyl Benzene	290	190	ND	32	8.5	4.3	0.2
Benzene	3.1	1.9	0.5	6.2	3.7	0.3	0.01
Methyl Cyclohexane	NA	NA	NA	NA	NA	NA	0.2
Total Hydrocarbons	2593.1	1061.9	25.5	458.2	103.2	43.4	2.9

BORING B8

	Sample Depth, Feet						
Chemical Compound	6	11	16	21	26	31	36
Toluene	0.5	430	0.06	0.4	4.5	0.3	0.05
Xylene	ND	550	0.2	7.5	8.7	0.9	0.05
Ethyl Benzene	0.3	200	0.4	16.0	0.81	0.1	ND
Benzene	ND	18	ND	0.2	2.3	0.7	0.1
Methyl Cyclohexane	1.0	1100	0.7	3.6	1.7	0.1	ND
Total Hydrocarbons	1.8	2298.0	1.4	27.7	18.0	2.1	0.2

NOTES:

1. ND = Not detected within laboratory limits.
2. NA = Not analyzed.
3. Analyzed by modified U.S. EPA Test Method 8020.

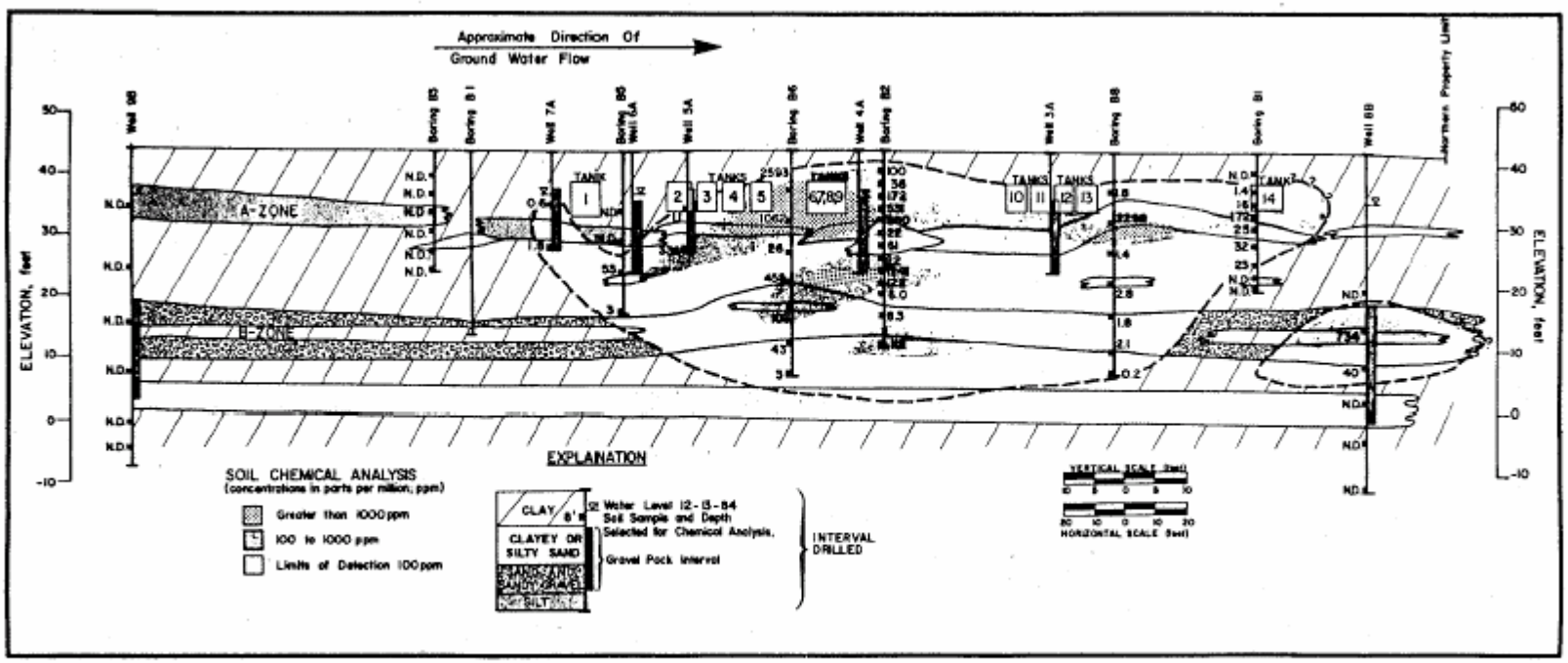
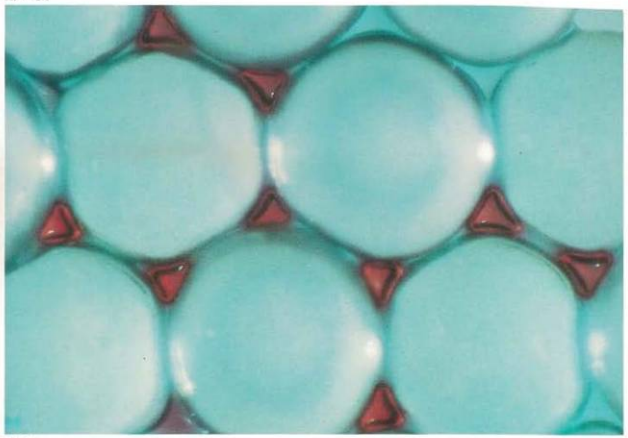


Figure 4: Distribution of Contaminants In Soil

Mechanisms of LNAPL movement at the site

XV.a.



XV.b.

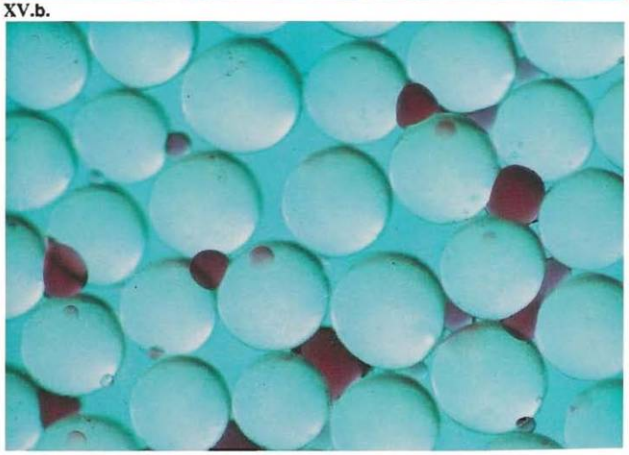
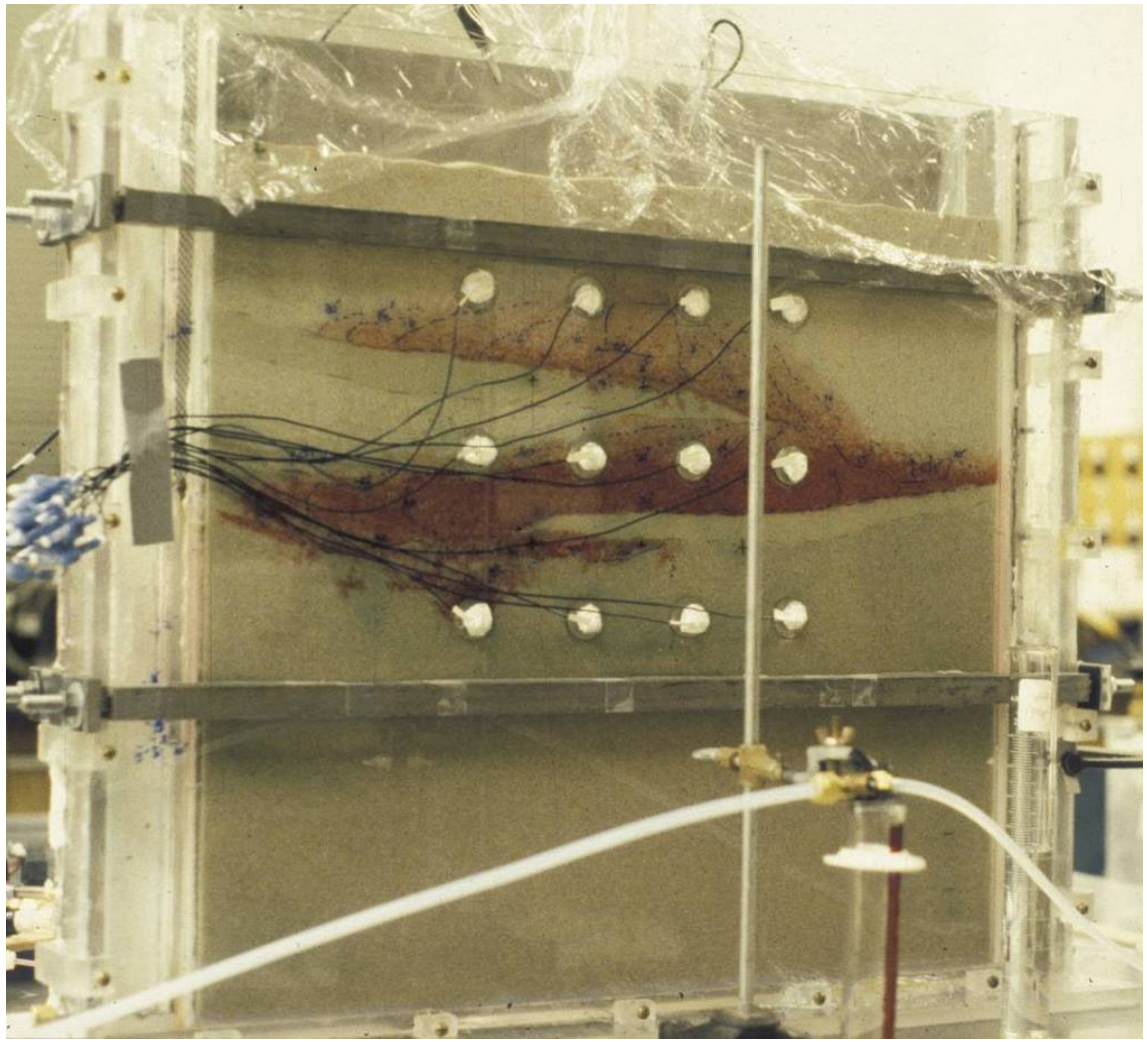


Figure XV.a. Beads initially moist; diameter range = 0.85 – 1.23 mm. PER then dripped in from above. Most of the PER flowed out, leaving isolated drops in the internal portions of the pore spaces.

Figure XV.b. Beads initially dry; diameter range = 0.85 – 1.23 mm. PER then dripped in from above; it occupied the corners of the pore spaces. Beads then saturated from below with water; PER thereby forced into the smaller pore spaces.



From Pantazidou 1993

Conclusions

- Principal release of solvents from the tanks occurred over 10 to 15 years prior to discovery during a period of low water table
- Separate phase liquids lighter than water can be trapped below the water table when the water table fluctuates
- Shallow clay and silty clay layers often contain fractures that act as conduits for contaminants and cannot be considered impermeable

What happened at the site?

- The tanks were emptied immediately after discover of leakage and they were eventually removed
- To soil immediately around the tanks was removed
- Groundwater recovery system was installed and pumping continues to this day.