

Trouble in Paradise Activity Sheet

The mythical town of Paradise is a rural township of about 5,000 people. Most residents run small farms or local services and businesses. The rolling countryside of the township has attracted urban workers in recent years from the nearby city of Crystal Springs and the town is experiencing its first major growth period in 20 years.

A small industrial area lies just west of downtown Paradise. This area includes a paint manufacturing company and a chemical plant. Both of these industries use water in their manufacturing processes and both produce chemical wastes. The paint and chemical companies were built in the late 1950's. In 1965, a municipal landfill was built west of the industrial site. The landfill accepted 500,000 cubic yards of municipal and industrial waste from 1966 until the landfill was covered in 1975.

The landfill site was sold to Jean Johnson for farming in 1977; the farm house was destroyed by fire in 1993, and the land was sold for suburban development in 1994. A gas station was opened near the farm site in 1995.

Through the early 1970's, all Paradise residents drew their drinking water from private wells. As more and more people moved into Paradise, residential neighborhoods expanded to the west and what had been farmland became suburban neighborhoods. In 1978 Paradise incorporated as a city. A new subdivision, Tranquil Acres, was developed between the industrial area and the Johnson farmsite during the early 1990's. Subdivision plans called for one high capacity well to serve the new homes. The well was installed in 1997 and began pumping water in February 1998.

In April 1998, members of the Hansen family began experiencing nausea, vomiting and blurred vision. The Hansen home is one of three remaining farms in Paradise and is located about ½ mile west of Tranquil Acres. Their home was built in the early 1900's and has its own private well. The Hansens suspected that their well water was causing their symptoms and in May 1998 they contacted the city health department. The city health department did not have the means to detect many contaminants, so they called in county health officials.

In June 1998, lab samples drawn by the county showed that the Hansen's well contained volatile organic compounds (VOC's), including trichloroethylene (TCE) and 1,2-dichloroethylene (1,2-DCE). The well samples contained 7 parts per billion (ppb) TCE and 350 ppb 1,2-DCE. County health officials advised the Hansen family to use bottled water for drinking and to minimize contact with water by taking shorter, cooler showers, running the exhaust fan during showers, ventilating the bathroom after showering, and opening kitchen windows when running the dishwasher.

VOC	Sources	Health effects	Wisconsin groundwater standard
1,2-dichloroethylene (1,2-DCE)	manufacturer of industrial solvents, coolant, breakdown product of TCE, landfill leachate	nausea, vomiting, weakness, tremors, liver and kidney damage, possible mutagen	70 ppb
Trichloroethylene (TCE)	paint remover, metal degreaser, dry cleaning solvent, manufacture of organic chemicals, landfill leachate	blurred vision, nausea, vomiting, damage to kidney, liver and nervous system, possible carcinogen	5 ppb



Between June 1998 and April 1999, local wells were monitored for VOC's. Each well was tested three times.

Well	June 1998		February 1999		April 1999	
	1,2 -DCE	TCE	1,2 -DCE	TCE	1,2 -DCE	TCE
Hansen's farm	350	7	50	0	0	0
Thompson's farm	70	0	188	1	290	1
Smith's farm	0	0	0	0	0	0
Paint company	0	0	0	0	0	0
High capacity well	0	0	0	0	0	0

Note: Results are in parts per billion (ppb)

The Hansen's well showed high levels of VOC's in June 1998, but only traces of VOC's in February 1999. By April 1999, the contaminants seemed to have disappeared from the Hansen well. In June 1999, the Smith's began to experience the same symptoms that the Hansens had experienced in 1998. The Smiths called the county health department to report the problem. Paradise officials decided a full scale investigation was in order. They feared that the contamination might be drawn toward the new high capacity well in the subdivision.

The area wells were sampled again in May and July 1999 with the following results:

Well	May 1999		July 1999	
	1,2 -DCE	TCE	1,2 -DCE	TCE
Hansen's farm	0	0	0	0
Thompson's farm	360	2	410	6
Smith's farm	200	0	260	1
Paint company	30	0	30	0
High capacity well	0	0	0	0

Note: Results are in ppb

Public health officials advised the Thompsons and the Smiths to use bottled drinking water and minimize contact with their well water. In addition to TCE and 1,2-DCE, water tests revealed that the Thompson's well was also contaminated with methane gas produced by decaying organic material. Methane gas can be carried underneath homes by groundwater where, in high enough concentrations, it can cause explosions.

After hearing the results of the health department tests, residents of Tranquil Acres formed a citizen action group. They feared that the high capacity well was in danger of being contaminated. After several meetings citizens petitioned the city to:

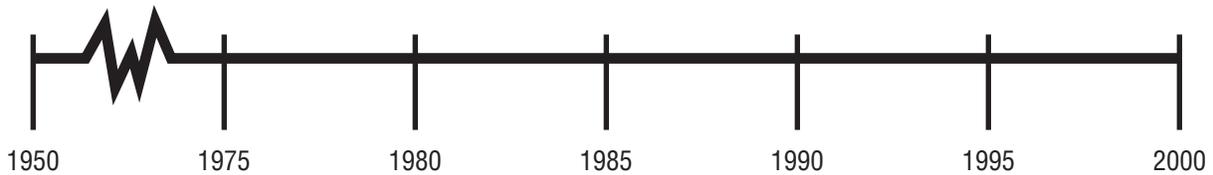
- 1) Guarantee that the VOC problem be solved before the contamination spread to the new community well.
- 2) Guarantee alternate sources of water for contaminated wells.
- 3) Guarantee purchase of affected properties to maintain property values if the contamination problem cannot be solved.



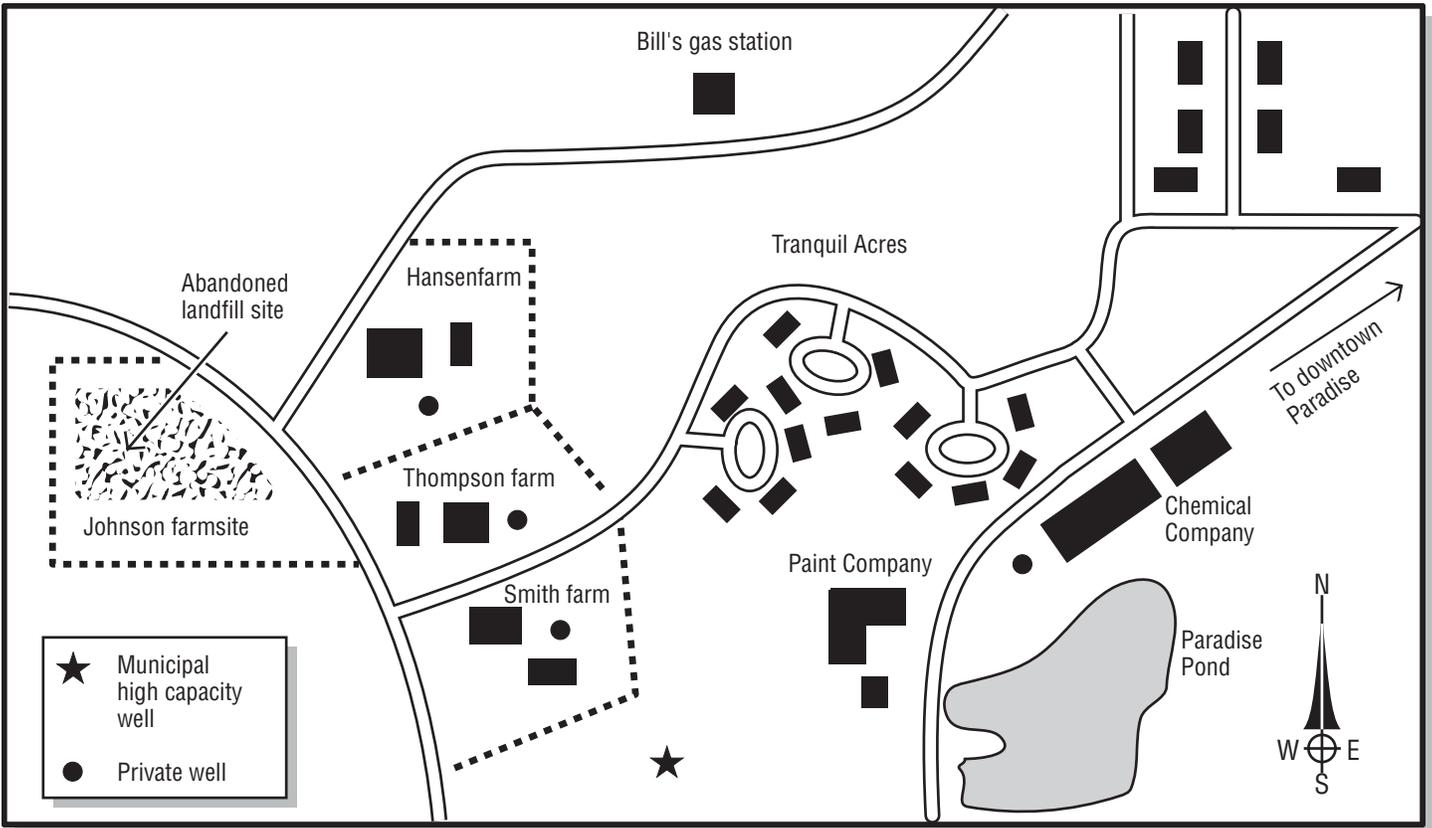
In August 1999, city council members determined that monitoring, testing and clean up could cost up to 3 million dollars. They have hired your company, the Contamination Busters, to help solve their groundwater problem before the community well is affected. Based on what you know about groundwater and the information you have been given, complete the following report sheet for the city council.

1. Place letters representing the following events on the timeline below:

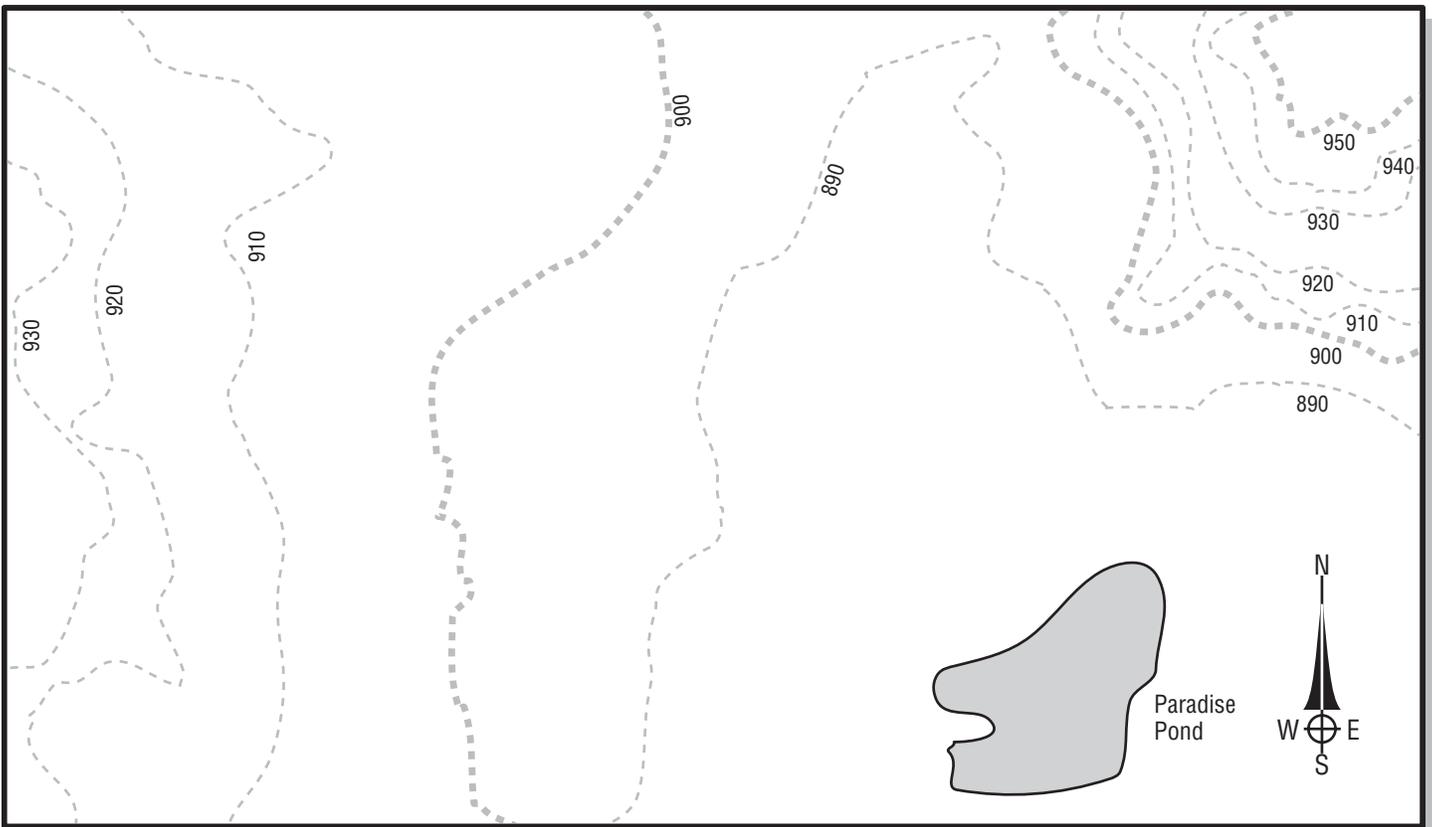
- A: Tranquil Acres is developed
- B: landfill is constructed
- C: citizens form action group
- D: landfill is covered
- E: Smiths contact health department
- F: local industries are built
- G: city council decides to take action
- H: high capacity well begins pumping
- I: Bill's gas station opens
- J: Hansens contact health department



2. Based on the topography of the Paradise area, draw an arrow on the map "B" showing the general direction of groundwater flow.



Map A



Map B



3. Complete the following tables.

Well	Parts per Billion 1,2-Dichloroethylene				
	June 1998	February 1999	April 1999	May 1999	July 1999
Hansen's farm					
Thompson's farm					
Smith's farm					
Paint company					
High capacity well					

Well	Parts per Billion Trichloroethylene				
	June 1998	February 1999	April 1999	May 1999	July 1999
Hansen's farm					
Thompson's farm					
Smith's farm					
Paint company					
High capacity well					

4. Circle all VOC levels on the tables above that exceed Wisconsin's groundwater standards.

5. Based on the information you have gathered, what is the source of VOC contamination?

6. With a **Red** pencil place X's on map "A" in places where you'd like to put monitoring wells to confirm the source of contamination.

7. Using the information on the data tables above, outline the plume of contamination before the high capacity well was built with a **blue** pencil. With a **green** pencil, outline the plume of contamination after the high capacity well was began pumping. Why did the plume change?



How Much is a Part per Billion? Activity Sheet

Many water quality standards are measured in parts per million (ppm), parts per billion (ppb) or even parts per trillion (ppt) of pollutant in a given quantity of water. Regardless of what is being measured, ppm, ppb or ppt mean that there is one part of something in a million, billion or trillion parts of something else. The following table will help you understand this concept:

Unit	ppm	ppb	1 ppt
length	1 inch in 16 miles	1 inch in 16,000 miles	1 inch in 16,000,000 miles (a 6 inch leap on a journey to the sun!)
time	1 minute in 2 years	1 minute in 2,000 years	1 minute in 20,000 centuries
money	1 cent in \$10,000	1 cent in \$10,000,000	1 cent in \$10,000,000,000

Very small amounts of some pollutants can harm people and wildlife.

For example:

ppm	ppb	ppt
If there is 1 ppm oil in the water, $\frac{1}{2}$ of the Dungeness crabs will be killed	At levels of 20 ppb of Mercury in their blood, humans show symptoms of mercury poisoning	Brook trout cannot grow properly or reproduce at levels of toxaphene over 39 ppt

Adapted from C. Revelle and P. Revelle, The Environment, 1988, p. 112-114, Boston: Jones and Bartlett Publishers, Inc.