Better Thames Network

Groundwater Workshop

Case Study 2 – Assessment of downward (?) trends – Poor to good status

Introduction

Pollution from chlorinated solvents has left a legacy of groundwater pollution that is still significantly impacting groundwater today. One area that has been well studied is the chlorinated solvent plume associated with waste disposal pits on the Chalk aquifer at Harwell, Oxfordshire. This pollution first came to light in the late 1980s when drinking water standards for chlorinated solvents were introduced. A plume of contaminated water was detected extending about five kilometres to a nearby public water supply. Since then a series of measures have been undertaken on site, such as groundwater containment and removal of the waste in the source area and thermal vapour extraction treatment of the unsaturated zone below the pits. Meanwhile the offsite plume has been monitored by the Environment Agency together with some 'receptor' control of abstractors both public and private. Consequently at most monitoring locations the pattern of solvent shows a clear decline with asymptotic curves such as shown in Figure 1 below. It should however be noted that levels still lie above drinking water standards at some offsite locations.

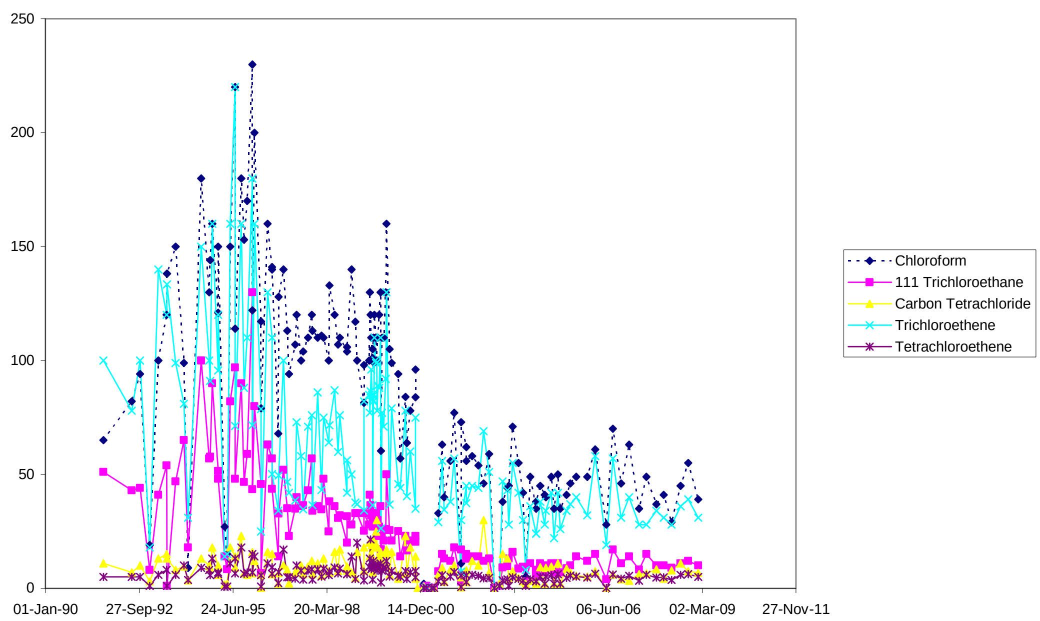


Figure 1 Data from an offsite monitoring well at Harwell showing the declining trends.

WFD investigations

In other areas of solvent contamination the patterns of declining solvent pollution might also be expected because of a greater awareness of the environmental impact of chlorinated solvents. This has lead to a reduction in the use of these substances and improved pollution prevention measures. In addition a general reduction in heavy industry in the UK has also assisted this decline. Therefore it was somewhat surprising that initial WFD reviews of water quality data in some areas of known chlorinated solvent pollution, such as Luton, appeared to identify rising trends.

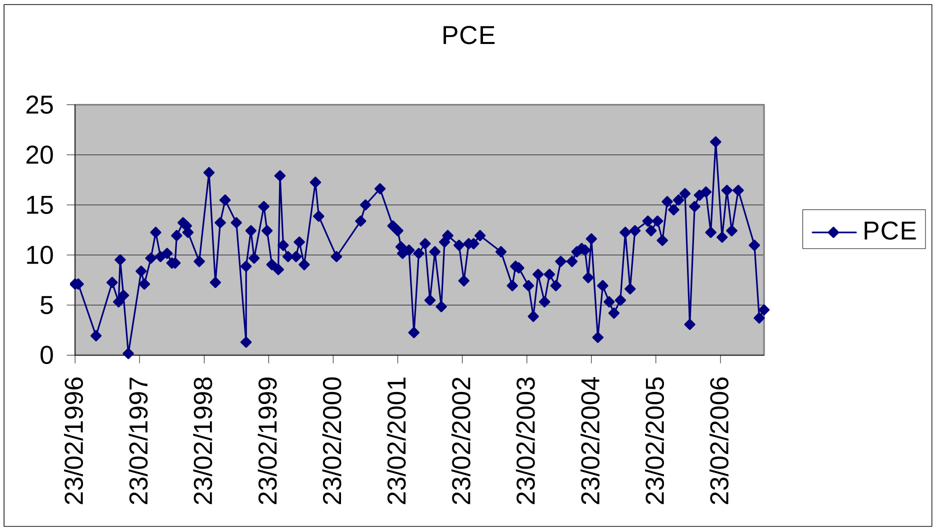


Figure 2 PCE plot at a monitoring well in Luton showing a rising trend

Closer inspection of the data for the same point over a longer time period appears to show that as the groundwater levels in the aquifer fluctuate this is mirrored by changes in solvent concentrations. High water levels appear to act to dilute the solvent presumably emanating from a sub-water DNAPL source.

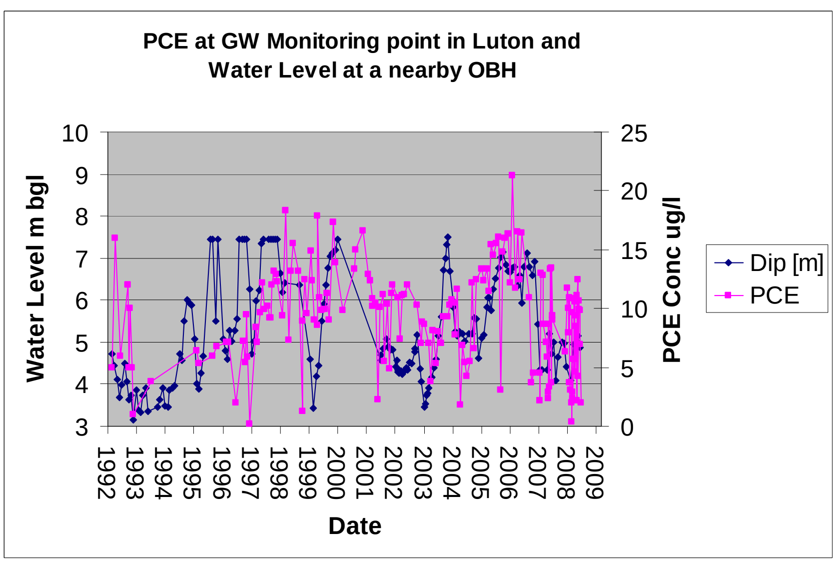


Figure 3 Figure showing apparent correlation of water levels and concentrations.
In addition Luton, like some other urban areas on the Chalk has a number of significant abstractions. Figure 4 shows the Source Protection Zones modelled

for Luton and it can be seen that most of the urban area overlies areas of the aquifer within the total catchment zone of one or other of the abstractions.

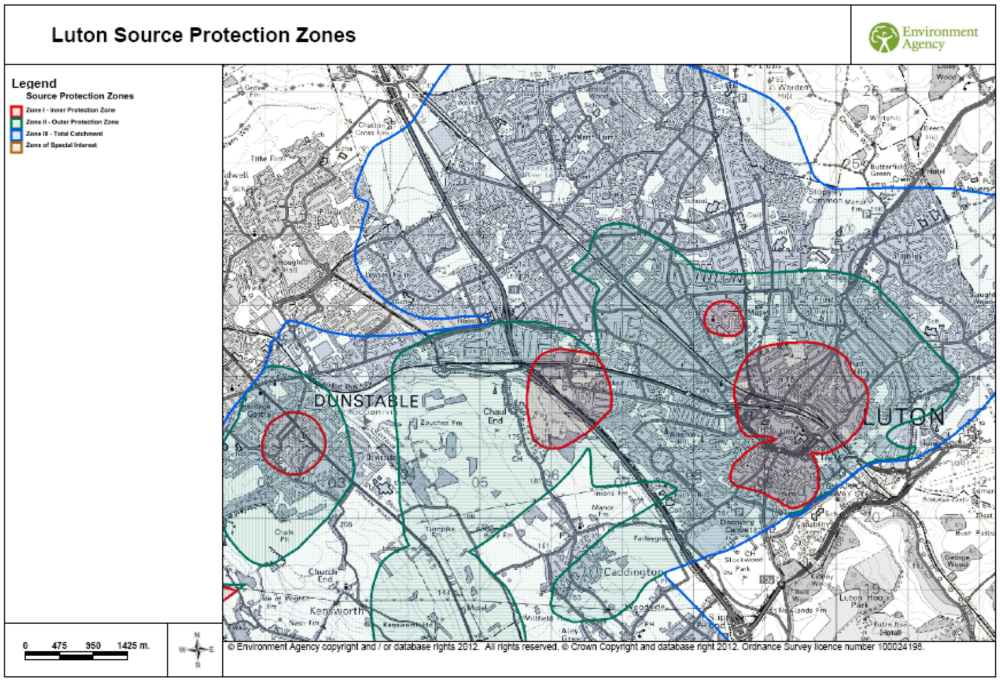
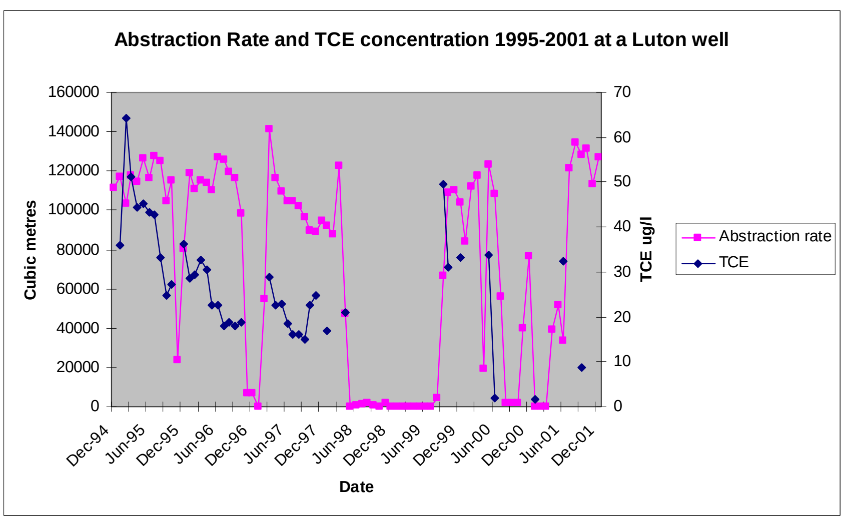


Figure 4 Luton area:- Total Catchment Zone lies within blue shaded boundaries.

The pumping history of any abstraction will vary due to changes in demand, shutdowns for maintenance etc. There appears to be some correlation between the abstraction regime and chlorinated solvent concentrations where prolonged periods of pumping tend to reduce contaminant levels and this presumably is due to either cleaner water being drawn in from more remote areas or perhaps shorter residence times for groundwater within the contaminated areas of the aquifer. Once again dilution in the aquifer appears to be a major factor.



Exponential decline?

Most chlorinated solvents are capable of undergoing degradation to daughter products through mechanisms such as reductive dechlorination. This would give rise to an exponential decline in concentration. However there is little evidence for significant concentrations of these daughter products in the groundwater samples (although often not sampled for) and therefore it is assumed there is little degradation of chlorinated solvents occurring in the deep aquifer.

Considerations

The aim of the WFD is reach good status by 2027 at the latest. Good status will be achieved when pollutant species do not demonstrate rising trends and fall below 75% of the threshold values (Drinking Water Protected Area) or 50% of the threshold values for a percentage of monitoring points with the groundwater body (General Chemical Test) . In the case of tetrachloroethene and trichloroethene this would require them to fall below a combined total concentration of either 7.5 ug/l or 5ug/l. A number of sites that fail the DrWPA test are candidates for Safeguard zones.

Workshop objectives

Question 1
What type of decline equation might be expected from dilution and dispersion of the pollutant alone in a dual porosity aquifer?

Question 2
How would you remove the effects of changing water levels and abstraction rates to obtained baseline declining plots to check the mathematical solutions for these graphs?

Question 3
Should the equations generated be based on worst case scenarios, such as drought and minimal abstraction, or the effects of climate change, since peaks and frequency of contaminant peaks often trigger the need for water treatment? Or should the equations be based on average conditions?

Question 4
If these curves predict breaches of threshold concentrations beyond 2027 what remedial measures might be appropriate?

Workshop Feedback

1) Delegates felt that the 10 year time period for reviewing data for WFD trend may be too short to adequately determine trend and suggested a longer time period ~30 years. However it was also noted that a longer time period may also hide the impact of any recently introduced improvement/remedial measures.

2) **Response to Question 1**: It was generally felt that a slug of contamination would lead initially to a rise in contaminant levels followed by an exponential decline. The length of time and levels of contamination at a point in the plume would depend on the degree of diffusion occurring, which to some extent within the Chalk would be governed by block size. When suggestions were put forward that the solutions for some of the trends appear to be power solutions rather than exponential solutions, delegates said it was possible these are correct but could not supply a mechanism. An inverse square power solution in declines observed at abstraction wells did seem feasible, as the effects of pumping declined or increased with pumping rate.

3) **Response to Question 2**: For the best way of cleaning up the data to remove the effect of changing groundwater levels (i.e. changing rainfall) it was felt to try and fit curves through either the extreme high values or low values to get two end member scenarios – worst case and best case.

4) **Response to Question 3**: Once an empirical solution for these curves were obtained a final solution based on an average with error bars was felt to be best approach for a final solution. The delegates accepted that this did not fully resolve the problem for public water abstractors who would need to install treatment after a threshold exceedance. However it was felt that costs should be appropriate as groundwater treatment also has an environmental impact on the carbon balance which should be also factored into the decisions.

5) **Response to Question 4**: Delegates felt there were not any really suitable remediation methods for contaminants that had migrated into the deep Chalk matrix. It was accepted that abstraction where it occurred coupled with treatment of supply is as good as any solution, even though it does not fit within the WFD goals.