



Memorandum

To: Ms. Maura O'Brien

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Date: December 13, 2010

Subject: Statistical analyses of PCE concentrations
Exceedance of performance standard evaluation

Introduction

This technical memorandum (TM) presents results of statistical analyses to assess Tetrachloroethene (PCE) concentrations in onsite groundwater at the former Tac-Sea Motel site, in particular, an evaluation of whether PCE concentrations exceed assessment standard levels equivalent to the Model Toxics Control Act (MTCA) 5 microgram per liter ($\mu\text{g/L}$) Method A cleanup level.

Assessment Period

Figure 1 is a time-series plot showing all PCE data obtained for the three onsite monitoring wells (MWA, MWB, MWC) at the site since the initiation of active treatment. This plot clearly shows that treatment has reduced PCE concentrations to low levels, Heading (Level 3) which have been effectively maintained over the last 5-6 years.

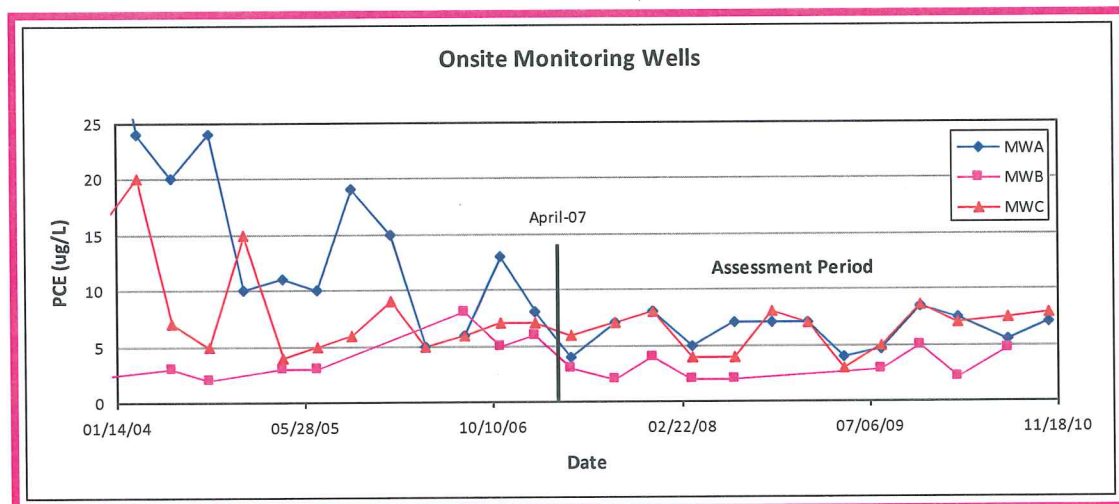


Figure 1 – Time-series plot for all onsite monitoring data.

Figure 2 is an enlargement of the time-series plot to better visualize the effective low PCE levels over the last 5-6 years. This plot shows that onsite PCE concentrations attain relatively stable levels beginning in about April 2007. This period of stabilized conditions (April 2007 to present) represents an appropriate assessment period for purposes of statistical analyses.

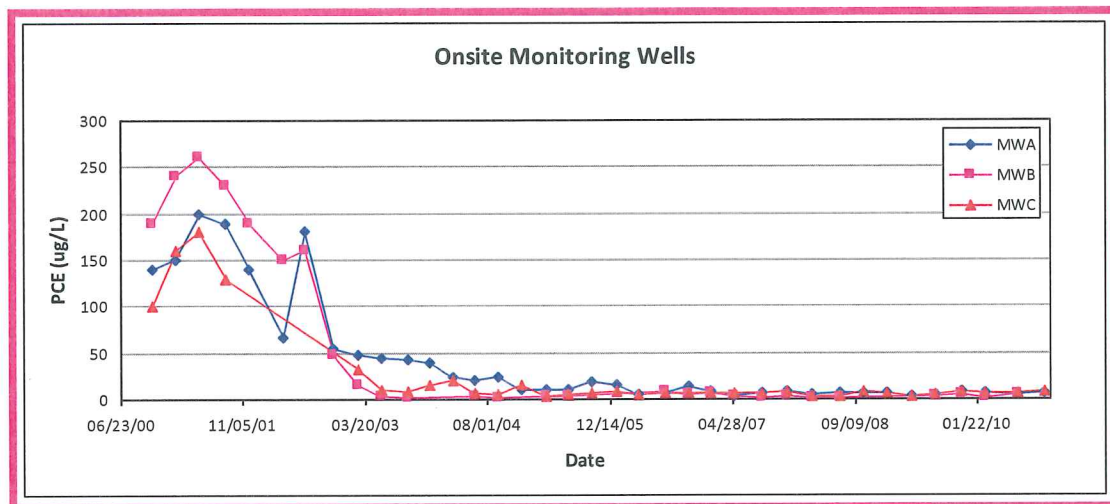


Figure 2 – Enlarged time-series plot with assessment period identified.

Grouped Well Analysis

Figure 3 is a time-series plot of the assessment period, showing the mean PCE concentrations for the three onsite wells at each sampling event. The error bars represent the data range (minimum and maximum measured values). These data points (grouped mean PCE) represent the data to be evaluated statistically in subsequent sections.

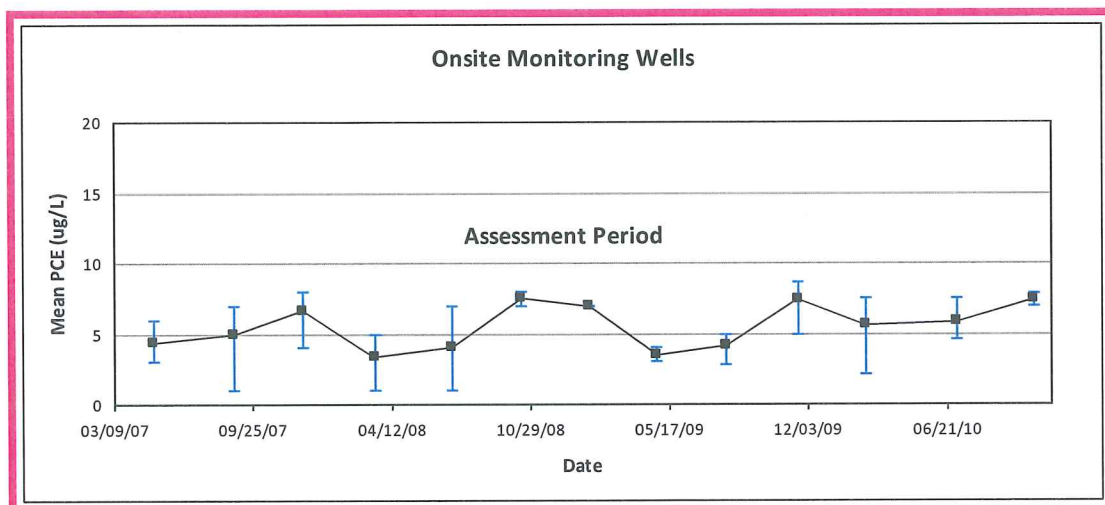


Figure 3 – Mean PCE concentrations in the assessment period.

The grouped mean time-series (Figure 3) indicates that during the assessment period PCE concentrations generally and randomly fluctuate ($\pm 2\text{-}3\text{ }\mu\text{g/L}$) about the $5\text{ }\mu\text{g/L}$ assessment standard. No trend (increasing or decreasing) is visually apparent. This was tested via the Theil-Sen trend analysis method (also called the Mann-Kendall method), results of which are provided in Table 1. The resulting p-value (0.200) is above the critical level of 0.05, thus indicating no statistically significant trend. This supports the stability of the data during the assessment period.

Table 1
Trend Analysis Results

Trend Analysis	Mean PCE ($\mu\text{g/L}$)
Theil-Sen	
Date	
Count	13
Intercept	-45.33850778
Slope	0.001268554
p-value	0.200128118
Kendall S	22
Var(S)	268.6666667
Kendall tau	0.282051282
Kendall tau-b	0.282051282

Figure 4 is a normal probability plot of the grouped means data, which indicates a relatively good fit with a normal distribution model. This was tested via three normality test methods, the results of which are provided in Table 2. The resulting p-values (0.140, 0.228, and 0.516) were all above the critical level of 0.05, thus indicating that the data pass the normality test. This supports use of parametric comparison analysis methods.

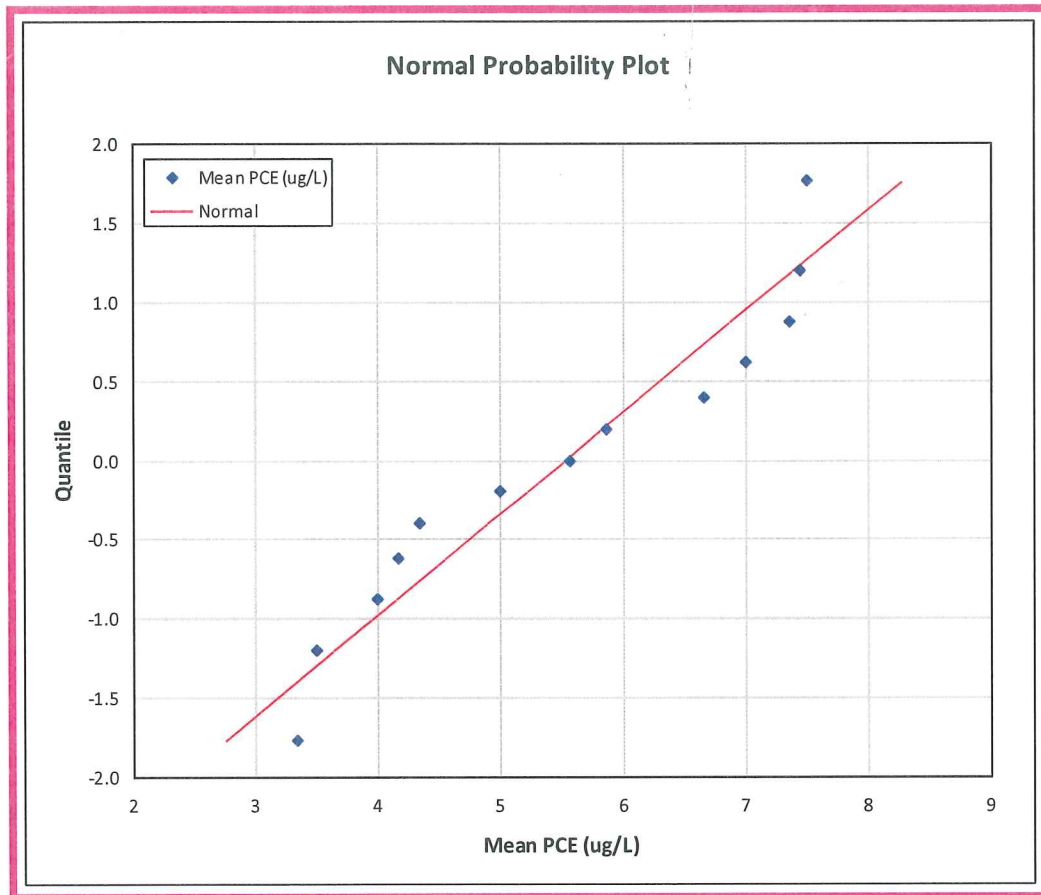


Figure 4 – Normal probability plot of grouped mean PCE data.

Table 2
Normality Test Results

Normality Test	Mean PCE (ug/L)
Count	13
Shapiro-Wilk W Statistic	0.901541441
p-value	0.140403804
Anderson-Darling A Statistic	0.484528963
p-value	0.227733383
Lilliefors D Statistic	0.160416051
p-value	0.516267922

Comparison Testing

The grouped mean PCE data were compared with the 5 µg/L assessment standard via a 1-sided parametric paired t-test to determine whether the mean PCE data during the assessment period significantly exceeded the assessment standard. The results (Table 3) indicate non-exceedence of the assessment standard (p-value = 0.127) at the 0.05 critical level (95% confidence level).

Table 3
Parametric Paired Comparison Results

Two-Group Comparison	Standard (ug/L)	Mean PCE (ug/L)
Parametric Paired		
Count	13	13
Mean	5	5.519230769
Standard Deviation (D)		1.564328133
Delta		0.519230769
df		12
Student t Statistic		1.196752218
p-value (1-sided)		0.127256005
p-value (2-sided)		0.254512011

To further support this conclusion, a 1-sided nonparametric sign test was also conducted. The results (Table 4) also indicate non-exceedence of the assessment standard (p-value = 0.250) at the 0.05 critical level (95% confidence level).

Table 4
Nonparametric Sign Test Results

Two-Group Comparison	Standard (ug/L)	Mean PCE (ug/L)
Sign		
Count	13	13
Count >		7
Count <		5
Count =		1
p-value (1-sided)		0.250315259
p-value (2-sided)		0.500630517

Summary and Conclusions

As presented in this TM, the evaluation of PCE data at the subject site leads to the following conclusions:

- Active treatment has effectively reduced onsite well PCE concentrations to low and stable levels that generally and randomly fluctuate ($\pm 2\text{-}3\text{ }\mu\text{g/L}$) about the $5\text{ }\mu\text{g/L}$ assessment standard.
- The low and stable PCE levels, which exhibit no statistically significant trend and fit a normal distribution model, provide an appropriate assessment period (April 2007 to present) for statistical evaluation.
- Both parametric and nonparametric statistical comparison results indicate that mean PCE concentrations during the assessment period do not significantly exceed the $5\text{ }\mu\text{g/L}$ assessment standard.

All statistical analyses and graphical displays provided in this TM were conducted and/or created using Microsoft Excel ® (see attached file *TacSea3.xls*) according to methods described in the references below.

References

EPA (2009). Statistical analysis of groundwater monitoring data at RCRA facilities, Unified Guidance. EPA 530-R-09-007.

Gilbert, R.O. (1986). Statistical methods for environmental pollution monitoring. Van Nostrand Reinhold, New York.