Memo

To:	Byung Maeng Washington State Dept. of Ecology Northwest Regional Office 3190 160th Avenue SE Bellevue, WA 98008-5452	Project:	8888.005
From: Tel: Fax: Date:	David Haddock (206) 342-1760 (206) 342-1761 October 10, 2008	cc:	Carl Bach, Boeing Ray Power, Boeing

Subject: Comparison of Passive Diffusion Bag (PDB) and Low-flow Groundwater Sampling Results – SWMU-172/174, Boeing Renton Facility

This technical memorandum summarizes the comparison of passive diffusion bag (PDB) groundwater sampling methods with low flow groundwater sampling methods at SWMU-172/174, as requested in e-mail communications between the Washington State Department of Ecology (Ecology) and Geomatrix Consultants, Inc., (Geomatrix) on April 17 and 18, 2008.

The first part of the memorandum covers the background on the rationale for collecting the groundwater samples at SWMU-172/174, and how the samples were collected during the past three quarterly sampling events. The second part of the memorandum provides an evaluation of the quarterly sampling data in the context of comparing past and present low-flow sample results to the PDB sample results. The final section presents the conclusions that can be drawn and our recommendations concerning collection of future groundwater samples using PDB samplers.

BACKGROUND

Monitoring wells at SWMU-172/174 include: GW081S, GW082S, GW083S, GW152S, GW153S, GW172S, and GW173S. Prior to 2008, SWMU-172/174 was last investigated during the Remedial Investigation (RI) (Weston, 2001)[1]. Groundwater samples were not collected from these groundwater monitoring wells from August 2000 through December 2007.

[1] Weston (Roy F. Weston, Inc.), 2001, Remedial Investigation Report, Boeing Renton Plant, Renton, Washington: Prepared for The Boeing Company, Boeing Shared Services Group, Energy and Environmental Affairs, August 10.

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These older groundwater monitoring wells at SWMU-172/174 (GW081S, GW082S, GW083S, GW172S, and GW173S) were also installed with longer than typical screens compared to the newer monitoring wells at the facility. The Boeing Company (Boeing) had some concern over the potential water quality differences in these wells with the longer screens. To investigate if these longer well screens influenced the quality of groundwater samples, Boeing installed a shallow/deep pair of PDB samplers in four of these five monitoring wells in December 2007 and all five of these monitoring wells in May 2008. PDB samplers use a sealed polyethylene bag filled with distilled water that is left within a monitoring well for at least 2 weeks. Volatile organic compounds (VOCs) have been shown to diffuse through the polyethylene and reach equilibrium with groundwater containing VOCs after being submerged in a well for a minimum period of 2 weeks. At other facilities, groundwater samples collected using PDB samplers are generally considered comparable to groundwater samples collected using low flow sampling methods (USGS, 2001)[2]. The purpose of collecting baseline PDB samples from these wells was to compare the concentration of VOCs present at the top versus the bottom of the screen interval for each well.

In the third quarter 2008 sampling event (August 2008), AMEC Geomatrix, Inc. (AMEC; formerly Geomatrix Consultants, Inc.) found that no PDBs were deployed, and these five wells were all sampled using low-flow techniques and the groundwater samples were collected using non-dedicated pumps. Low-flow samples were collected from the bottom of the well screen interval.

In addition, Geomatrix collected additional groundwater samples using push probes at SWMU-172/174 in April 2008 as part of the Pre-CAP Investigation. These grab groundwater samples were collected from push probes PP170, PP172, PP173, and PP174, which were installed at approximately the same locations as the older RI push probes PP008, PP006, PP061, and PP062, respectively, that were installed in 1999 to 2000.

EVALUATION

Groundwater sample VOC analytical results for groundwater samples collected at SWMU-172/174 are presented in Tables 1 and 2. These sample results include groundwater samples:

- Collected during the RI in 1999 and in 2000 from groundwater monitoring wells using low flow methods, and as grab samples from push probes;

[2] USGS (U.S. Geological Survey), 2001, User's Guide for Polyethylene-Based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells, Water-Resources Investigations Report 01–4060, Volume 1.

- Collected during the quarterly groundwater monitoring samples in February, May, and August 2008 from groundwater monitoring wells using PDB samplers (February and May) and low flow techniques (August); and

- Collected during the Pre-CAP investigation from push probes in April 2008.

The VOCs listed in Tables 1 and 2 include 1,1-dichloroethene, benzene, chloromethane, *cis*-1,2-dichloroethene, methylene chloride, tetrachloroethene, trichloroethene, and vinyl chloride. All of these VOCs are constituents of concern (COCs) for SWMU-172/174.

The PDB results listed in Table 1 include results for samples collected from PDBs placed in the upper ("top PDB") and lower ("bottom PDB") portions of the screened interval, as well as results for samples collected using low-flow methods from the bottom of the well screen interval. Table 2 shows a comparison of push probe grab groundwater analytical results from 1999 to 2008.

As stated earlier, 2008 push probe locations were meant to replicate 1999 push probe locations. As shown in Table 2, the push probe groundwater results from 2008 are generally lower in concentration than the RI push probe results, with the exception of PCE concentrations. Push probe groundwater results from the RI compared to the 2008 Pre-CAP investigation show a similar decrease in COC concentrations as the low-flow and PDB groundwater samples, suggesting that the observed decrease in concentration in groundwater samples is real and not an artifact of the sample collection techniques.

Concentrations of VOCs have decreased by at least 50% in groundwater samples collected since the RI. Therefore, in order to provide the most meaningful comparison of the PDB and low flow sample results, we compared the 2008 results from two wells that had PDB and low flow groundwater samples with detectable concentrations of VOCs—GW082S and GW172S. As shown in Table 1:

- Of the wells with consistent detections (*cis*-1,2-DCE, PCE, TCE, and VC in GW082 and GW172) in 2008, low flow results were slightly higher than either top PDB or bottom PDB results in 18 of 32 observations, and low flow results were either the same or lower than top PDB or bottom PDB results in 14 of the 32 observations. It should be noted that for most analytes tested, PDB and low flow results were very similar in magnitude, had several identical detections, and sometimes were only 0.1 µg/L apart.

- The PDB sample results show very similar concentrations in the upper versus the lower sampling intervals for these wells for the first and second quarters of 2008. However, there is a marginal difference in concentrations between the PDB samples collected near the top and the bottom of the screens when they are compared to low flow results. For the two wells with consistent detections for all samples (GW082 and GW172), the low flow result was higher than the bottom PDB result 8 out of 16 times, and higher than the top PDB result 10 out of 16 times. The low flow result was lower or the same as the

bottom PDB result 8 out of 16 times, and lower or the same as the top PDB result 6 out of 16 times.

CONCLUSIONS

The following conclusions can be drawn from RI groundwater results and 2008 groundwater results as shown in Tables 1 and 2 and in Figure 1:

- Analytical results for VOCs collected using PDBs are generally comparable to groundwater samples collected using the low flow sampling methods. Low flow groundwater monitoring well results from 2008 are very similar to 2008 PDB groundwater monitoring well results, and are within a range that is expected for variability of groundwater sampling and analysis.

- Although top and bottom PDB results are very similar, there is a marginal difference in concentrations between the PDB samples collected near the top and the bottom of the screens, when they are compared to low flow results. In general, the bottom PDB and bottom low-flow results are somewhat higher than top PDB results and therefore are considered more representative of groundwater concentrations.

RECOMMENDATIONS

The PDB sampling results are generally comparable to the low flow sampling results. Both groundwater sampling methods are appropriate for sampling VOCs, and the PDB sample results should be considered capable of providing representative sample results. If the PDB sampling method is chosen for wells at SWMU-172/174, AMEC recommends that only one PDB sampler be deployed at the lower portion of the well screens, since the bottom PDB groundwater results are more comparable to results from samples collected using low flow methods.

Attachments:

Table 1 – Comparison of groundwater monitoring well analytical results (RI and Post-RI)
Table 2 – Comparison of push probe grab groundwater analytical results (RI and Post-RI)
Figure 1 – PDB and Low Flow Comparison SWMU 172/174

TABLE 1

COMPARISON OF GROUNDWATER MONITORING WELL ANALYTICAL RESULTS (RI AND POST-RI) SWMU-172/174[1,2,3]

Boeing Renton Facility

Renton, Washington

Results in micrograms per liter (µg/L)

Location ID	Sample Method	Sample Date	1,1-DCE	Benzene	Chloromethane	cis-1,2-DCE	MC	PCE	TCE	VC
GW081	low flow	3/3/1999	1 U	1 U	2 U	1 U	2 U	PCE U	1 U	2 U
GW081	low flow	6/2/1999	1 U	1 U	1 U	1 U	2 U	1 U	1 U	1 U
GW081	low flow	9/10/1999	1 U	1 U	1 U	1 U	2 U	1 U	1 U	1 U
GW081	low flow	8/23/2000	1 U	1 U	1 U	1 U	2 U	1 U	1 U	1 U
GW081	bottom PDB	2/18/2008	0.2 U	0.2 U	0.2 U	0.2 U	0.3 U	0.2 U	0.2 U	0.2 U
GW081	top PDB	2/18/2008	0.2 U	0.2 U	0.2 U	0.2 U	0.3 U	0.2 U	0.2 U	0.2 U
GW081	bottom PDB	5/14/2008	0.2 U	0.2 U	0.2 U	0.2 U	0.5 U	0.2 U	0.2 U	0.2 U
GW081	top PDB	5/14/2008	0.2 U	0.2 U	0.2 U	0.2 U	0.5 U	0.2 U	0.2 U	0.2 U
GW081	low flow	8/11/2008	0.2 U	0.2 U	0.2 U	0.2 U	0.5 U	0.2 U	0.2 U	0.2 U
GW082	low flow	3/3/1999	1 U	1 U	2 U	**1.6**	2 U	**6.1**	**11**	2 U
GW082	low flow	6/2/1999	1 U	**1.7**	**16 J**	1 U	**12**	**6.5**	**6.9**	1 U
GW082	low flow	9/9/1999	1 U	1 U	1 U	1 U	2 U	**5.6**	**4.4**	1 U
GW082	low flow	8/24/2000	1 U	1 U	1 U	1 U	2 U	**5.8**	**3**	1 U
GW082	bottom PDB	2/18/2008	0.2 U	0.2 U	0.2 U	**0.8**	0.3 U	**0.5**	**0.5**	**0.8**
GW082	top PDB	2/18/2008	0.2 U	0.2 U	0.2 U	**0.4**	0.3 U	**0.7**	**0.3**	**0.5**
GW082	bottom PDB	5/14/2008	0.2 U	0.2 U	0.2 U	**0.3**	0.5 U	**0.2**	**0.2**	**0.4**
GW082	top PDB	5/14/2008	0.2 U	0.2 U	0.2 U	**0.3**	0.5 U	**0.5**	**0.2**	**0.3**
GW082	low flow	8/11/2008	0.2 U	0.2 U	0.2 U	**0.8**	0.5 U	**0.5**	**0.3**	**0.4**
GW083	low flow	8/24/2000	1 U	1 U	1 U	1 U	2 U	1 U	1 U	**2.2**
GW083	bottom PDB	5/14/2008	0.2 U	0.2 U	0.2 U	**0.2**	0.5 U	0.2 U	0.2 U	**0.3**
GW083	top PDB	5/14/2008	0.2 U	0.2 U	0.2 U	0.2 U	0.5 U	0.2 U	**0.2 U**	**0.4**
GW083	low flow	8/11/2008	0.2 U	0.2 U	0.2 U	0.2 U	0.5 U	0.2 U	0.2 U	0.2 U
GW172	low flow	8/23/2000	1 U	1 U	1 U	**34**	2 U	**8.6**	**8.6**	**34**
GW172	bottom PDB	2/18/2008	0.2 U	0.2 U	0.2 U	**1.2**	0.3 U	**0.4**	**0.8**	**1.9**
GW172	top PDB	2/18/2008	0.2 U	0.2 U	0.2 U	**1.4**	0.3 U	**0.4**	**0.7**	**2.1**
GW172	bottom PDB	5/14/2008	0.2 U	0.2 U	0.2 U	**1.5**	0.5 U	**1.4**	**1.8**	**0.7**
GW172	top PDB	5/14/2008	0.2 U	0.2 U	0.2 U	**1.3**	0.5 U	**1.1**	**1.4**	**0.8**
GW172	low flow	8/11/2008	0.2 U	0.2 U	0.2 U	**5.8**	0.5 U	**0.6**	**1.7**	**1.8**
GW173	low flow	8/23/2000	1 U	1 U	1 U	**2.9**	2 U	**1.2**	**1.1**	**4.5**
GW173	bottom PDB	2/18/2008	0.2 U	0.2 U	0.2 U	0.2 U	0.3 U	0.2 U	0.2 U	**0.3**
GW173	top PDB	2/18/2008	0.2 U	0.2 U	0.2 U	0.2 U	0.3 U	**0.4**	0.2 U	**0.3**
GW173	bottom PDB	5/14/2008	0.2 U	0.2 U	0.2 U	0.2 U	0.5 U	**0.3**	**0.2**	0.2 U
GW173	top PDB	5/14/2008	0.2 U	0.2 U	0.2 U	0.2 U	0.5 U	1.7 U	1 U	0.2 U
GW173	low flow	8/11/2008	0.2 U	0.2 U	0.2 U	**0.4**	0.5 U	0.2 U	**0.3**	**0.4**
GW152	low flow	6/2/1999	1 U	1 U	1 U	**100**	2 U	**53**	**54**	1 U
GW152	low flow	8/24/2000	1 U	1 U	1 U	**270**	2 U	**25**	**93**	**2.8**
GW152	low flow	5/14/2008	0.2 U	0.2 U	0.2 U	**14**	0.5 U	**6**	**1.3**	**8**
GW152	low flow	8/11/2008	**0.2**	0.2 U	0.2 U	**150**	0.5 U	**2.3**	**0.8**	**270**
GW153	low flow	6/2/1999	1 U	1 U	1 U	1 U	2 U	**2.9**	1 U	1 U
GW153	low flow	8/24/2000	1 U	1 U	1 U	**1.4**	2 U	1 U	1 U	**2.4**
GW153	low flow	5/14/2008	0.2 U	0.2 U	0.2 U	**0.3**	0.5 U	**1.9**	**0.5**	**0.3**
GW153	low flow	8/11/2008	0.2 U	0.2 U	0.2 U	0.2 U	0.5 U	**0.7**	0.2 U	**0.7**

Notes

1. [ ] = samples collected in 2008.
2. Results in **bold** indicate detection above the reporting limit.
3. Data qualifiers are as follows:
   U = analytical results below the reporting limit.
   J = esimated value; value to the left is the reporting limit.

Abbreviations

1,1-DCE = 1,1-dichloroethene
cis-1,2-DCE = cis-1,2-dichloroethene
MC = methylene chloride
PCE = tetrachloroethene
PDB = passive diffusion bag
TCE = trichloroethene
VC = vinyl chloride

TABLE 2

COMPARIXON OF PUSH PROBE GRAB GROUNDWATER ANALYTICAL RESULTS (RI AND POST-RI) SWMU-172/174[1, 2, 3]

Boeing Renton Facility
Renton, Washington

Results in micrograms per liter (µg/L)

Location ID	Sample ID	Sample Date	1,1-DCE	Benzene	Chloromethane	cis-1,2-DCE	MC	PCE	TCE	VC
PP008	R-GW01-PP008-0120	5/21/1999	1 U	1 U	1 U	1 U	2 U	1 U	1 U	1 U
PP008	R-GW01-PP008-0180	5/21/1999	1 U	1 U	1 U	1 U	2 U	**7.3**	1 U	1 U
PP170	PP170-GW	4/24/2008	0.2 U	0.2 U	0.2	**2**	0.5 U	**9**	**1.2**	**0.4**
PP006	R-GW01-PP006-0120	5/21/1999	1 U	1 U	1 U	**51**	2 U	**300**	**33**	1 U
PP006	R-GW01-PP006-0180	5/21/1999	1 U	1 U	1 U	1 U	2 U	1 U	1 U	1 U
PP172	PP172-GW	4/24/2008	0.2 U	0.2 U	0.2 U	**10**	0.5 U	**65**	**7.9**	**0.7**
PP061	R-GW15-PP061-0120	8/8/2000	**3.8**	1 U	1 U	**2500**	2 U	**100**	**1900**	**22**
PP173	PP173-GW	4/24/2008	0.2 U	0.2 U	0.2 U	**110**	0.5 U	**380**	**28**	**1**
PP062	R-GW15-PP062-0120	8/8/2000	1 U	1 U	1 U	**1.1**	2 U	**3.6**	**1 J**	1 U
PP174	PP174-GW	4/24/2008	0.2 U	0.2 U	0.2 U	0.2 U	0.5 U	**7.8**	**0.3**	0.2 U
PP005	R-GW01-PP005-0120	5/26/1999	1 U	1 U	1 U	**41**	2 U	**180**	**19**	**3**
PP005	R-GW01-PP005-0170	5/26/1999	1 U	1 U	1 U	1 U	2 U	1 U	1 U	1 U
PP007	R-GW01-PP007-0170	5/26/1999	1 U	1 U	1 U	**2.4**	2 U	1 U	**32**	1 U

Notes

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Abbreviations

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cis-1,2-DCE = cis-1,2-dichloroethene
MC = methylene chloride
PCE = tetrachloroethene
TCE = trichloroethene
VC = vinyl chloride

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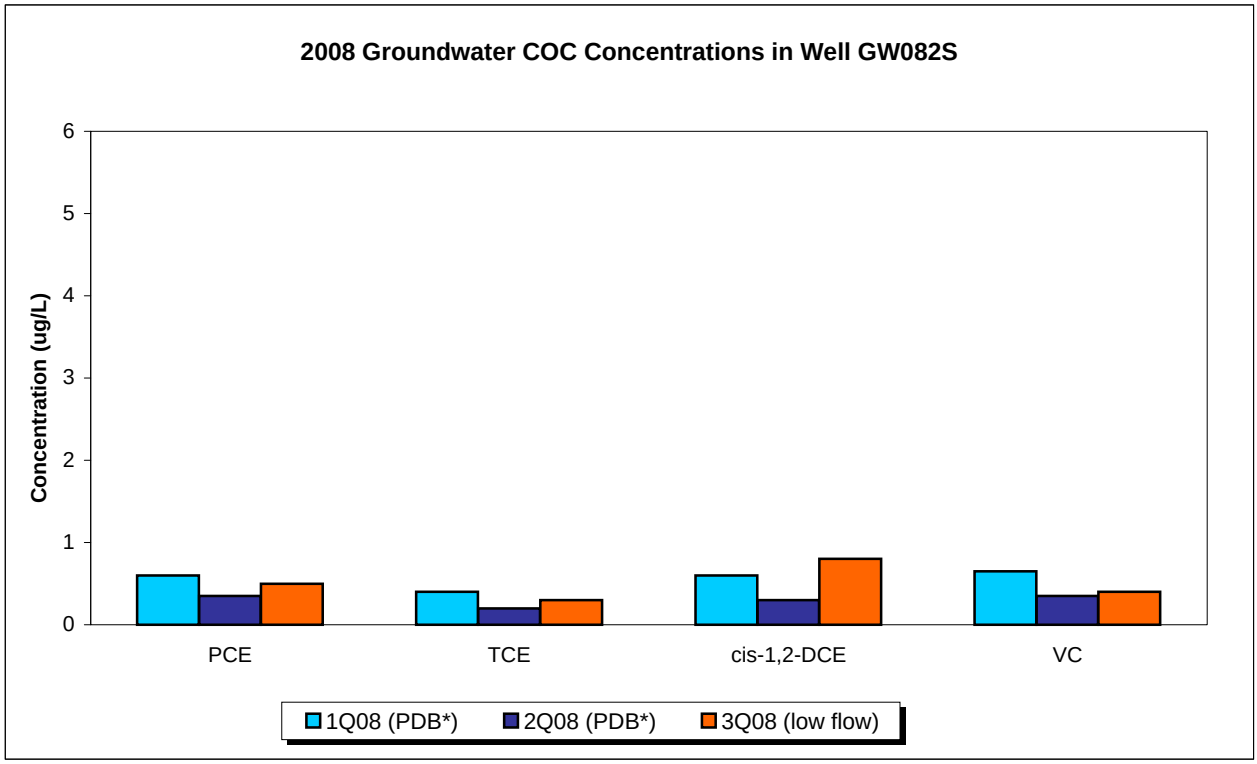

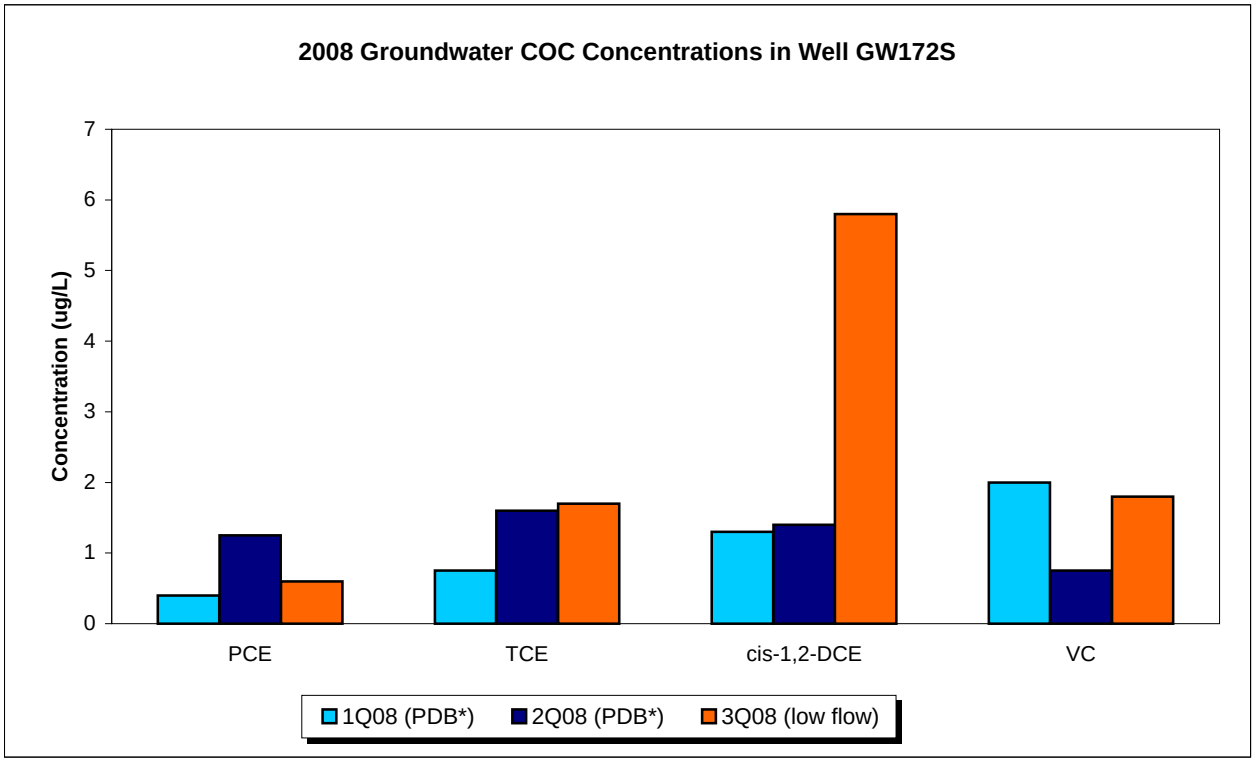

* Concentrations in top and bottom PDB samples were averaged.

PDB and Low Flow Comparison
SWMU-172/174
Boeing Renton Facility
Renton, Washington

By: ZAS	Date: 09/22/08	Project No.: 8888
AMEC Geomatrix		Figure 1