Comments on the *Final Proposed Plan for LHAAP-35B(37), Chemical Laboratory and LHAAP-67, Aboveground Storage Tank Farm, Longhorn Army Ammunition Plant, Karnack, Texas*, June 9, 2008

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These comments are based on evaluations of the final proposed plan for Longhorn Army Ammunition Plant (LHAAP) sites LHAAP-35B(37) and LHAAP-67, as well as supporting documents (see references). General comments are presented first, followed by comments specific to each site.

Between 1942 and 1997, explosives, pyrotechnic devices (flares, photoflash bombs), and propellants (rocket motors) were manufactured at LHAAP[1]. Groundwater at both sites is contaminated with constituents associated with these activities[2]. The primary contaminants of concern (COCs) at both sites are solvents (e.g., TCE, PCE, 1,1-DCE).

The Army's preferred remedial alternative for both sites is Alternative 2[3]. Under this alternative, natural attenuation (MNA)[4] would be relied on to reduce concentrations of groundwater contaminants, and land use controls (LUCs) would be maintained until contaminant concentrations were reduced to acceptable levels (MCLs)[5]. The estimated cost of this alternative is $282,000 for site 35B(37), and $316,000 for site 67[6].

General Comments

1. Sampling frequency

There does not appear to have been a systematic, well thought-out plan for investigating groundwater contamination at these sites. Groundwater monitoring has been infrequent and irregular. At site 35B(37), groundwater has been sampled only seven times since 1994[7]. At site 67, groundwater has been sampled only five times since 1998[8]. Sample collection dates for each site are listed in table 1.

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[1] EPA 2009a, page 3.
[2] United States Army, 2008b, pages 5 and 9.
[3] United States Army, 2008b, page 12.
[4] MNA: monitored natural attenuation.
[5] United States Army, 2008b, page 17. MCL: EPA maximum contaminant limit for drinking water.
[6] United States Army, 2008b, page 13.
[7] Shaw, 2007c, page 5-8. Note: no individual well was sampled more than six times.
[8] Shaw, 2007c, page 5-15. Note: no individual well was sampled more than four times.

Table 1
Groundwater sampling dates at LHAAP-35B(37) and LHAAP-67

LHAAP-35B(37)	LHAAP-67
December 1994	December 1998
August 1996	December 2000
May 1998	September 2004
November 1998	August 2006
September 2004	December 2006
August 2006	
December 2006	

The Army should establish a regular monitoring schedule. A regular schedule is required to identify any seasonal variations in water quality and water levels.

2. Reporting limits

The reporting limits[9] used for the analyses of contaminants in groundwater samples were often higher than the limits established to protect human health (MCL). This could result in a failure to detect the presence of contaminants (false negative analyses). Table 2 lists examples of reporting limits that were too high.

Table 2
Examples of High Reporting Limits

Contaminant[10]	Well	Date	Reporting Limit	MCL[11]	Reference
Antimony	LHSMW58	12/11/94	100 µg/L	6 µg/L	Shaw, 2007b, Appx. D
Thallium	LHSMW59	8/21/96	90 µg/L	2 µg/L	Shaw, 2007b, Appx. D
Bis(2-ethylhexyl) phthalate	35BWW01	11/8/98	10 µg/L	6 µg/L	Shaw, 2007b, Appx. D
Vinyl chloride	35BWW03	12/16/06	10 µg/L	2 µg/L	Shaw, 2007c, page 5-9

The Army should not use reporting limits that are greater than MCLs or other values established to protect human health or the environment.

[9] Reporting limits (aka practical quantitation limits) are typically five times higher than detection limits.
[10] Note: At site 35B(37) no analyses of antimony, cadmium, selenium, or thallium appear to have been performed after 1998 (Shaw, 2007b, Appx. D; Shaw, 2007c, page 5-9). At site 67 no analyses of antimony, cadmium, selenium, or thallium appear to have been performed after 2000 (Shaw, 2007b, Appx. D; Shaw, 2007c, page 5-16).
[11] EPA, 2006a.

3. Incomplete analyses

Several wells do not appear to have ever been sampled for potential COCs. Table 3 lists the wells and the potential COCs for which they have not been analyzed.

Table 3
Wells Lacking Analyses for Potential COCs[12]

Well	Potential COCs not analyzed
35BWW03	Antimony, thallium
35BWW04	Antimony, thallium
35BWW05	Antimony, thallium
35BWW06	Antimony, thallium
All wells at site 67	Antimony

The wells listed above should be sampled for the potential COCs.

4. Time to achieve cleanup goals

The time required for natural attenuation to reduce contaminant concentrations to MCLs at both sites could be many decades, or even centuries[13]. It is not reasonable to propose plans that could require the maintenance of LUCs for such lengths of time.

5. Modeling: general

The following comment applies to all modeling performed for LHAAP sites 35B(37) and 67.

The models used to predict the transport of contaminants in groundwater assume homogeneous and isotropic conditions.[14] That is, they assume that hydraulic properties (e.g., hydraulic conductivity, porosity) are everywhere the same throughout the aquifer. As a result, the models do not account for the preferential pathways[15] (i.e., fast flow paths) that probably exist at the LHAAP (e.g., buried stream channels). Flow of contaminants along preferential pathways would result in higher concentrations of contaminants in surface water that is affected by contaminated groundwater.

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[12] Shaw, 2007b, Appx. D; Shaw, 2007c, pages 5-9 and 5-16.
[13] United States Army, 2008b, page 13.
[14] Shaw, 2007a, pages 4-12 and 4-15.
[15] The EPA directive on MNA states that preferential pathways should be accounted for when evaluating the suitability of a site for MNA: "*Site characterizations for natural attenuation generally warrant a quantitative understanding of source mass; groundwater flow (including preferential pathways); contaminant phase distribution and partitioning between soil, groundwater, and soil gas; rates of biological and non-biological transformation; and an understanding of how all of these factors are likely to vary with time.*" EPA, 1999, page 13.

6. Modeling: time to reach MCLs

The following comment applies to the modeling of the time required for natural attenuation to reduce groundwater contaminant concentrations to MCLs.

The model simulated two types of contaminant sources: 1) an instantaneous source, and 2) a continuous source that persists for ten years[16]. The continuous source results in more conservative (longer) estimates of the time required to reach MCLs. However, the Army provides no data or information to justify either an instantaneous source or a source that persists for only ten years. High concentrations of contaminants have persisted at site 35(B)37 for more than ten years, and at site 67 for more than eight years (see attached figures 1 through 4)[17]. Given the persistence of contaminants at both sites, the Army should explain why it limited the continuous source in the model to only ten years.

7. Modeling: transport of groundwater contaminants to streams

The following comments apply to modeling of the transport of groundwater contaminants to Goose Prairie Creek (site 35B(37)) and Central Creek (site 67).

- The model assumes instantaneous and complete mixing of contaminated groundwater and surface water[18]. Instantaneous mixing is unlikely to occur. Instead, complete mixing of contaminated groundwater and surface water may not occur until the contaminated water has flowed hundreds or thousands of feet downstream. Contaminant concentrations will be higher near the portion of the stream that receives contaminated groundwater than they will be at some point downstream, after complete mixing has occurred.

- The models use estimates of hydraulic conductivities derived from slug tests.[19] Estimates of hydraulic properties based on slug test data are subject to large errors.[20] Slug test data are often affected by a 'skin effect' that is caused by incomplete development.[21] This results in estimates of hydraulic conductivity that are too low. Because calculated groundwater flow rates are directly proportional to the hydraulic conductivity, the groundwater flow rates calculated by the Army are probably low. As a result, groundwater contaminants will probably reach the streams sooner, and in higher concentrations, than the Army has predicted[22].

[16] United States Army, 2008a, enclosure 4, page 1.
[17] Shaw, 2007c, pages 5-8 and 5-15.
[18] Shaw, 2007a, page 4-16.
[19] Shaw, 2007a, Appendix E, page 2-1.
[20] EPA 1993, page 1; and Butler, 1997, pages 4 and 5.
[21] Butler 1997, pages 4 and 5.
[22] The most reliable method of estimating hydraulic conductivity is the pumping test. According to the EPA: "*The most reliable type of aquifer test usually conducted is a pumping test. In addition, some site studies involve the use of short term slug tests to obtain estimates of hydraulic conductivity, usually for a specific zone or very limited portion of the aquifer. It should be emphasized that slug tests provide very limited information on the hydraulic properties of the aquifer and often produce estimates which are only*

- The Army does not appear to have performed a sensitivity analysis on it's modeling of groundwater/surface water interactions. In a sensitivity analysis, the values of model parameters (e.g., half-lives, hydraulic conductivity) are varied within reasonable ranges and the effects of these variations on model results are evaluated. If model results vary significantly in response to reasonable variations in parameter values, the results may not be reliable.[23]

8. Remedial Design, monitoring, and contingency plans

- It is difficult to evaluate effectiveness of any proposed plan without also evaluating the Remedial Design (RD). The RD should include descriptions of monitoring programs, MNA performance objectives, land use controls, contingency remedies, etc. However, it appears that the RD will be developed after the preferred alternative is chosen[24]. Given the uncertainty associated with MNA, the development of effective monitoring programs, performance objectives, and contingency remedies is essential. The Army should make the RD available for public review and comment as soon as possible.

- The proposed plan does not refer to a schedule or criteria (performance objectives) for evaluating the effectiveness of MNA. Nor does it mention the development of a contingency plan to be invoked if MNA is not meeting the performance objectives. These items should be included in the RD.

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accurate within an order of magnitude. Many experts believe that slug tests are much too heavily relied upon in site characterization and contamination studies. This group of professionals recommends use of slug testing during the initial site studies to assist in developing a site conceptual model and in pumping test design." EPA 1993, page 1.

[23] The EPA directive on MNA states the following regarding sensitivity analyses: "*Because of the complexity of natural systems, models necessarily rely on simplifying assumptions that may or may not accurately represent the dynamics of the natural system. Calibration and sensitivity analyses are important steps in appropriate use of models."* EPA, 1999, page 14.

[24] United States Army, 2008b, page 18.

Site-specific Comments

LHAAP-35B(37)

1. Extent of Contaminant Plume Unknown

Groundwater at this site flows to the south and southeast[25]. The southern monitor wells (LHSMW58 and 35BWW04) contain high concentrations of contaminants[26]. However, there are no monitor wells down gradient of these wells. Therefore, the full extent of the contaminant plume at LHAAP-35B(37) is unknown.

The Army should install additional monitor wells down gradient of wells LHSMW58 and 35BWW04.

2. Natural attenuation

- The proposed plan states that contaminant levels will be reduced to MCLs in approximately 40 years[27]. The uncertainty associated with this estimate is an order of magnitude[28]. That is, the time to achieve MCLs could range from 4 years to 400 years. It is not reasonable to propose a plan that could require the maintenance of LUCs for many decades or centuries.

- The Army states: "*Natural attenuation has effectively controlled plume migration and appears to have stabilized the VOC plume.*".[29] This statement is not based on fact. The extent of the contaminant plume at LHAAP-35B(37) is unknown (see above).

- The Army is relying on natural attenuation to improve water quality at LHAAP-35B(37). In some cases, natural attenuation does appear to have substantially reduced contaminant concentrations (1,1-DCE at well LHSMW58, PCE at well LHSMW59)[30]. However, in other cases, contaminant concentrations have either not appreciably decreased (TCE and PCE at well LHSMW58, see attached figures 1 and 2)[31], or they initially decreased and then stabilized (TCE at well LHSMW59, see attached figure 3)[32]. In still other cases, only one analytical result is available (TCE and PCE at well 35BWW04, TCE at well 35BWW05). Thus, it is not possible to determine whether natural attenuation is occurring in the vicinity these wells. The data do not support the Army's contention that natural attenuation will reduce contaminant concentrations to acceptable levels[33].

[25] United States Army, 2008a, enclosure 1, figure 1.
[26] Shaw, 2007c, page 5-8.
[27] United States Army, 2008b, page 13.
[28] US Army, 2008b, page 13. An order of magnitude is a factor of ten.
[29] United States Army, 2008b, page 5.
[30] Shaw, 2007c, page 5-8.
[31] Shaw, 2007c, page 5-8.
[32] Shaw, 2007c, page 5-8.
[33] United States Army, 2008b, page 17.

3. Modeling transport of groundwater contaminants to Goose Prairie Creek

- The Army states that groundwater at site 35(B)37 flows to the east-northeast[34], and that the travel distance from the contaminant plume to the creek is 125 feet[35]. However, groundwater at site 35(B)37 flows to the south-southeast[36], and the contaminant plume appears to extend beyond the creek[37]. The Army's use of of 125 feet results in predictions of contaminant concentrations that are lower than would be predicted if a shorter distance (or a distance of 0 feet) were used.

- The Army assumed that the areal extent of the plume was 350 feet by 200 feet[38]. However, the full extent of the plume at site 35(B)37 is unknown (see above).

- The model used contaminant half-lives (degradation rates) that were taken from the literature[39]. These half-lives are inconsistent with contaminant concentrations measured in monitor wells at the site. These inconsistencies are illustrated in attached figures 1 through 3. These figures show the measured concentrations, and the concentrations that would be expected if the half-lives assumed by the Army were controlling concentrations. There are two possible explanations for the inconsistencies. First, there may be a source that replaces the contaminants as they are degraded. Second, the half-lives assumed by the Army are unrealistically short. The Army should explain why the observed concentrations are inconsistent with the assumed half-lives.

- The Army assumed an instantaneous, rather than a continuous, contaminant source. This assumption results in lower predicted contaminant concentrations. There does not appear to be any data to justify this assumption. The Army should explain why it chose to use this assumption in the model.

- The model predicted that PCE emanating from the source at site 35(B)37 would be undetectable by the time it reached the creek. However, the PCE concentration at well 35BWW04, which is approximately 30 feet from the creek[40], was 30.1 µg/L[41]. This is six times higher than the MCL[42]. Thus, the model prediction appears to be contradicted by the data.

The modeling performed by the Army is not realistic[43]. It should be re-done.

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[34] Shaw, 2007a, appendix E, page 1-1.
[35] Shaw, 2007a, appendix E, page 2-1.
[36] United States Army, 2008a, enclosure 1.
[37] Shaw, 2007c, figure 5-6.
[38] Shaw, 2007a, appendix E, page 2-1.
[39] Shaw, 2007a, Appendix E, table 1.
[40] Shaw, 2007c, figure 5-6.
[41] Shaw, 2007c, page 5-8.
[42] The MCL for PCE is 5 µg/L (EPA, 2006a).
[43] It should be noted that the Army used the highest measured contaminant concentrations in the model (Shaw, 2007a, appendix E, page table 2). This is a conservative assumption in that it would result in

4. Antimony and thallium

The Army does not consider antimony and thallium to be COCs because " … *detections of thallium and antimony in groundwater were low and also J-qualified (i.e., the reported values were estimated values since they were below the reporting limit). Furthermore, although groundwater samples collected during multiple sampling events were analyzed for metals, thallium and antimony were only detected during one event*.".[44]

There are problems with this explanation.

First, the detected concentrations were not low. Antimony was detected at 80 (J) µg/L and 55 (J) µg/L[45]. The MCL for antimony is 6 µg/L[46]. Thallium was detected at 98 (J) µg/L[47]. The MCL for antimony is 2 µg/L[48].

Second, the concentrations were J-qualified[49] because the reporting limits were too high. If appropriate reporting limits were used, the values would not have been J-qualified.

Third, groundwater was analyzed for antimony and thallium in only four of seven sampling events[50]. In most cases, the reporting limits were higher than the MCLs for both antimony and thallium[51]. Groundwater at site 35(B)37 has not been analyzed for either antimony and thallium since 1998[52]. Four of the eight wells at the site have never been analyzed for antimony or thallium[53].

The Army's rational for not considering antimony and thallium to be COCs is weak. All wells at the site should be sampled, or re-sampled, for antimony and thallium. The reporting limits should be no higher than the MCLs.

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higher predicted concentrations. However, most of the Army's assumptions are non-conservative. That is, they would result in lower predicted concentrations.

[44] United States Army, 2008b, pages 6-7.

[45] Detected at wells LHSMW58 and LHSMW59, respectively (Shaw, 2007b, Appx. D).

[46] EPA, 2006a.

[47] Detected at well LHSMW58 (Shaw, 2007b, Appx. D).

[48] EPA, 2006a.

[49] The 'J' qualifier means that the analyte is present but the concentration is estimated. This qualifier is used when the concentration is above the method detection limit but below the reporting limit (aka practical quantitation limit). Reporting limits are typically five times higher than detection limits.

[50] Shaw, 2007b, Appx. D; Shaw, 2007c, page 5-9.

[51] Shaw, 2007b, Appx. D.

[52] Shaw, 2007b, Appx. D; Shaw, 2007c, page 5-9.

[53] Wells 35BWW03, 35BWW04, 35BWW05, 35BWW06 have not been sampled for either antimony or thallium (Shaw, 2007b, Appx. D; Shaw, 2007c, page 5-9).

LHAAP-67

1. Natural attenuation

- The proposed plan states that contaminant levels will be reduced to MCLs in approximately 60 years[54]. The uncertainty associated with this estimate is an order of magnitude[55]. That is, the time to achieve MCLs could range from 6 years to 600 years. It is not reasonable to propose a plan that could require the maintenance of LUCs for many decades or centuries.

- The Army is relying on natural attenuation to improve water quality at LHAAP-67. Natural attenuation does appear to have substantially reduced the concentrations of most contaminants at site 67[56]. However, 1,1-DCE concentrations remain high[57] (see attached figure 4). Thus, the data do not appear to support the Army's contention that natural attenuation will reduce all contaminant concentrations to acceptable levels[58].

2. Classification of groundwater

There are three classes of groundwater in Texas: Class 1, Class 2, and Class 3[59]. Class 3 groundwater is not considered to be a drinking water resource and does not receive the same degree of protection as Class 1 and Class 2 groundwater[60].

According to the Texas Commission on Environmental Quality (TCEQ), if wells in a groundwater bearing unit (GWBU) cannot produce at least 150 gallons per day, the groundwater in the GWBU is Class 3[61]. The TCEQ has established testing methods to determine whether wells in a GWBU can produce 150 gallons per day[62].

The Army tested three wells in the uppermost GWBU at site 67 to determine whether they could, on average, produce 150 gallons per day. They tested the wells using TCEQ method 2a: *Well yield by Cyclic Discharge*[63]. According to the Army, the wells could not produce 150 gallons per day and the groundwater " *... is likely to be a Class 3 groundwater resource.*"[64]. However, there are problems with the Army's tests.

[54] United States Army, 2008b, page 13.
[55] US Army, 2008b, page 13. An order of magnitude is a factor of ten.
[56] Shaw, 2007c, page 5-15.
[57] Shaw, 2007c, page 5-15.
[58] United States Army, 2008b, page 17.
[59] TCEQ, 2010a, page 1.
[60] TCEQ, 2010a, page 4.
[61] TCEQ, 2010a, page 5. Groundwater is also Class 3 if the total dissolved solids (TDS) content is greater than 10,000 ppm. The TDS content in the uppermost GWBU at site 67 ranges from 1570 ppm to 2070 ppm (United States Army, 2008a, enclosure 1, page 4).
[62] TCEQ, 2010a, page 27.
[63] United States Army, 2008a, enclosure 1, page 1.
[64] United States Army, 2008a, enclosure 1, page 4.

First, the Army did not follow the testing procedure required by TCEQ. Method 2a requires that a minimum of three bail-down/recovery cycles be performed on each well[65]. The Army performed only two bail-down/recovery cycles on each well[66].

Second, the tests were conducted during a period when the saturated thickness of the uppermost GWBU was low. The amount of water that can be produced by an aquifer is directly proportional to its saturated thickness. Thus, a lower saturated thickness will result in lower well production. The table below shows the saturated thickness at each well during the testing period (December 2007) and during September 2004 – the only other period for which water levels could be found.

Table 4
Comparison of Saturated Thicknesses

Well	Depth of well (ft-btoc) [67]	Depth to water during test (ft-btoc) [68]	Saturated thickness during test (ft)	Depth to water during September 2004 (ft-btoc)[69]	Saturated thickness during September 2004 (ft)
67WW01	26.69	24.02	**2.67**	21.16	**5.53**
67WW02	27.50	22.63	**4.87**	19.71	**7.79**
67WW05	30.45	23.25	**7.20**	20.24	**10.21**

The saturated thickness in September 2004 was between 140% and 200% greater than it was when the tests were performed. If the testing had been performed in September 2004, the wells probably would have produced more than 150 gallons per day.

The Army 1) performed the tests incorrectly, and 2) performed them at a time when the saturated thickness of the GWBU was low. Thus, the test results are invalid. They should not be used to classify the groundwater in the uppermost GWBU.

3. Antimony and thallium

The Army has not thoroughly investigated antimony or thallium in groundwater at site 67.

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[65] TCEQ, 2010a, pages 32 and 34.

[66] United States Army, 2008a, enclosure 1. See "Well Yield By Cyclic Discharge Field Form" for wells 67WW01, 67WW02, and 67WW05. Note, at first glance it appears that the Army performed three cycles on each well. However, closer examination of the 'begin pumping' and 'well dry' times (5th and 6th columns on the forms) shows that only two cycles were performed. See figure 7 in TCEQ, 2010a for clarification.

[67] United States Army, 2008a, enclosure 1. See "Well Yield By Cyclic Discharge Field Form" for wells 67WW01, 67WW02, and 67WW05. Btoc: below top of casing.

[68] United States Army, 2008a, enclosure 1. See "Well Yield By Cyclic Discharge Field Form" for wells 67WW01, 67WW02, and 67WW05.

[69] Shaw, 2007b, table 3-1.

None of the seven wells at site 67 were sampled for antimony[70]. Four of the wells were not sampled for thallium[71].

No wells have been sampled for thallium since 2000[72].

Although thallium was detected at a concentration higher than the MCL[73], the Army does not mention this in the discussion of COCs for the site[74].

All wells at site 67 should be sampled, or re-sampled, for antimony and thallium.

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[70] Shaw, 2007b, Appx. D; Shaw, 2007c, page 5-16.
[71] Shaw, 2007b, Appx. D; Shaw, 2007c, page 5-16.
[72] Shaw, 2007b, Appx. D; Shaw, 2007c, page 5-16.
[73] On 12/18/98, thallium was detected in well 67WW03 at 2.1 µg/L (Shaw, 2007b, Appx. D). The MCL is 2 µg/L (EPA, 2006a).
[74] United States Army, 2008b, page 11.

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United States Army, 2008b, *Final Proposed Plan for LHAAP-35B (37), Chemical Laboratory and LHAAP-67, Aboveground Storage Tank Farm, Longhorn Army Ammunition Plant, Karnack, Texas*, June 9, 2008.

Figures

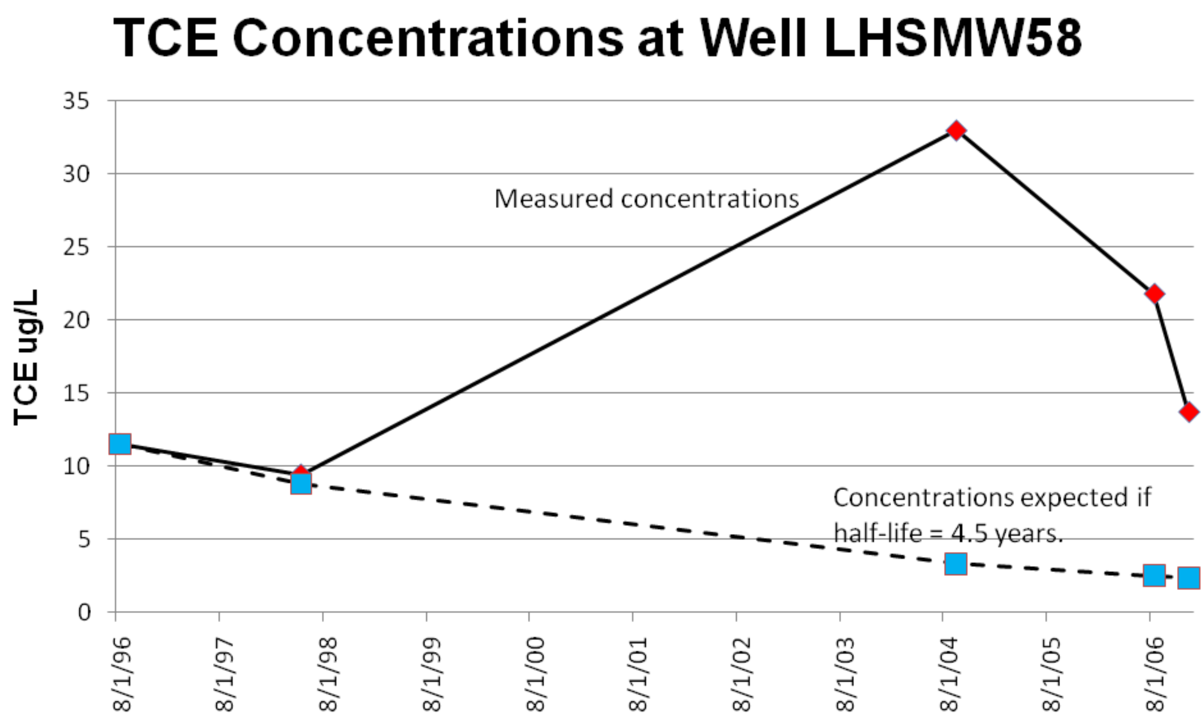

Figure 1

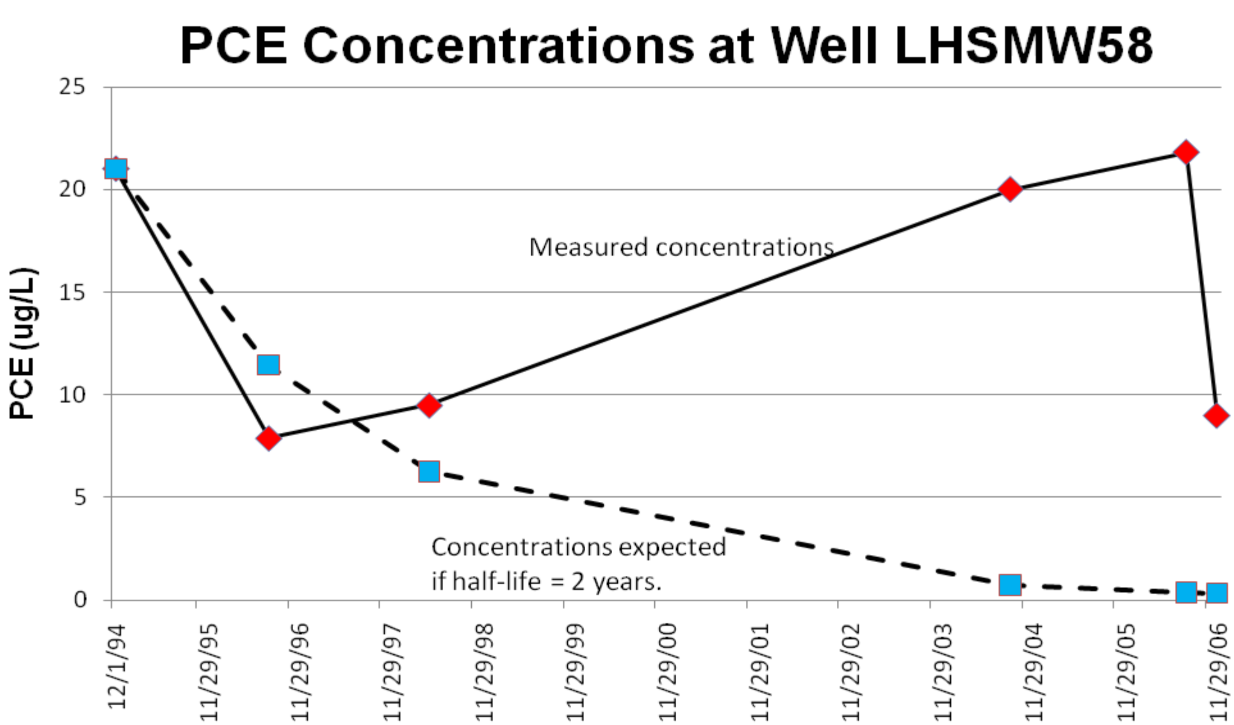

Figure 2

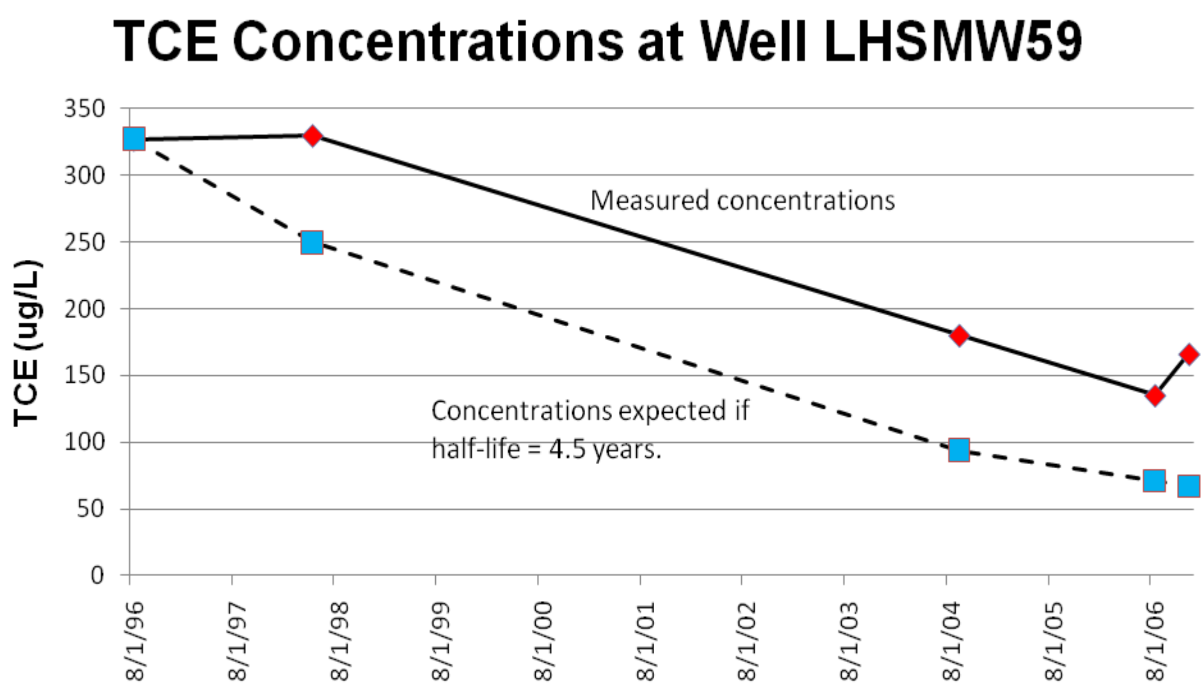

Figure 3

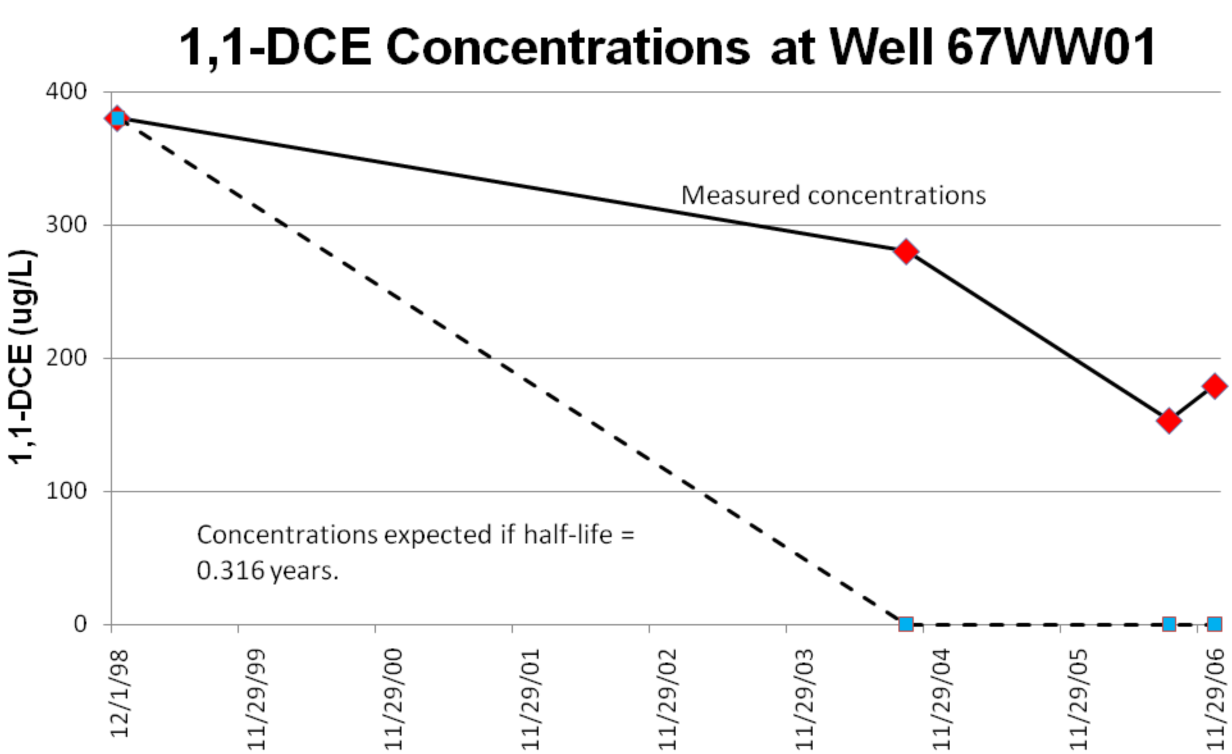

Figure 4