Comments on Proposed Final Plans for LHAAP Sites 35A(58), 46, and 50

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These comments are based on evaluations of final proposed plans for Longhorn Army Ammunition Plant (LHAAP) sites 35A(58), 46, and 50, as well as supporting documents (see references). General comments are presented first, followed by comments specific to each site.

General Comments

1. Report organization and clarity

   - The proposed plans and supporting documents are generally well organized and clearly presented.

2. Time to achieve cleanup goals

   - The Army is proposing to rely on monitored natural attenuation (MNA) to reduce contaminant concentrations to acceptable levels (MCLs[1] or other appropriate standards[2]). Land use controls (LUCs) would be imposed at each site until concentrations fall to MCLs.[3] However, at sites LHAAP-35A(58) and LHAAP-50, the time required to reach MCLs could be many decades, or even centuries[4]. It is not reasonable to propose plans that could require the maintenance of LUCs for such lengths of time.

3. Modeling assumptions

   The Army used both conservative and non-conservative assumptions in it's modeling of the fate and transport of groundwater contaminants. Non-conservative assumptions are:

   - The models use contaminant half-lives (degradation rates) that are taken from the literature.[5] In many cases, these literature-derived half-lives are shorter than half-lives derived from site-specific data. For example, the data-derived half-life for 1,1-DCE at LHAAP-35A(58) is 21 years[6]. This is more than 50 times longer than the literature value used in the model

[1] MCLs = EPA maximum contaminant limit for drinking water.
[2] Other standards are used when MCLs do not exist for a contaminant (see, for example, Shaw, 2009b, page 3-7 for a discussion of perchlorate).
[3] US Army, 2010a, page 9; US Army, 2010b, page 9; and US Army, 2010c, page 10.
[4] US Army, 2010a, page 13; US Army, 2010c, page 14.
[5] Shaw, 2007a, Appendix D, table 1.
[6] Shaw, 2009a, Appendix A, table A-3.

(0.362 years)[7]. As a result, the model predicts much more rapid degradation of 1,1-DCE than would be predicted if the data-derived half-life were used.[8]

- The models use estimates of hydraulic conductivities derived from slug tests.[9] Estimates of hydraulic properties based on slug test data are subject to large errors.[10] Slug test data are often affected by a ‘skin effect’ that is caused by incomplete development.[11] 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 receptors sooner, and in higher concentrations, than the Army has predicted.[12]

- The models used to predict the transport of contaminants in groundwater assume homogeneous and isotropic conditions.[13] 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[14] (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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[7] Shaw, 2007a, Appendix D, table 1.

[8] Using the literature-derived half-life, the concentration of 1,1-DCE falls from 1340 µg/L (the source term used in the model (Shaw, 2007a, Appendix D, table 1)) to 7 µg/L (the MCL) in about 15 years. Using the data-derived half-life, the concentration of 1,1-DCE falls from 1340 µg/L to 7 µg/L in about 160 years.

[9] Shaw, 2007a, Appendix D, page 2-1; Shaw, 2007a, Appendix G, page 2-1; Shaw 2009c, page 1-3.

[10] EPA 1993, page 1; and Butler, 1997, pages 4 and 5.

[11] Butler 1997, pages 4 and 5.

[12] 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 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.

[13] Shaw, 2007a, pages 4-12 and 4-15.

[14] 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.

- The model assumes instantaneous and complete mixing of contaminated groundwater and surface water.[15] 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 non-conservative assumptions listed above result in lower estimates of future contaminant concentrations in both surface water and groundwater.

4. Sensitivity analysis

- The Army does not appear to have performed a sensitivity analysis on it's modeling results.[16] 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.[17]

5. Standards

- The RDX standard used in the evaluations is 26 µg/L.[18] However, the EPA's Health Advisory (HA) level for RDX is 2 µg/L.[19] Although the HA is not an enforceable MCL, it is reasonable to assume that, when established, the value of the MCL will be similar to the 2 µg/L HA. The Army should explain why it did not use the RDX HA level in its evaluations.

- The Army uses three standards for perchlorate; one for groundwater (72 µg/L)[20] and two for surface water (4 µg/L[21] and 26 µg/L[22]). However, the EPA's HA level for perchlorate is 15 µg/L[23]. Although the HA is not an enforceable MCL, it is reasonable to assume that, when established, the MCL will be similar to the HA. The Army should explain why it did not use

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[15] Shaw, 2007a, page 4-16.
[16] Shaw, 2007a, appendices D, G, and J.
[17] 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.
[18] Shaw, 2007a, Appendix D, table 1.
[19] EPA, 2006, page 6.
[20] Shaw, 2009b, page 3-7.
[21] Shaw, 2007a, Appendix D, table 2; Appendix G, table 1; Appendix J, table 2.
[22] Shaw, 2009c, page 1-10.
[23] Interim lifetime health advisory level (EPA, 2008, page 1).

the perchlorate HA level in its evaluations, and why it uses two standards for surface water.

6. Potential use of groundwater

- The Army does not believe that groundwater system at the LHAAP is productive enough to be used as a water supply. They state: "*It is unlikely that impacted groundwater at the site would be used as a water supply since it is present in narrow sand lenses that probably are low yield*."[24] This statement does not appear to be based on an analysis of groundwater yield at the site. If the Army wishes to determine the productivity of the groundwater system at the LHAAP, it should perform the necessary tests and analyses.

7. Remedial Designs, monitoring MNA, and contingency remedies

- It is difficult to evaluate effectiveness of any proposed plan without also evaluating the Remedial Designs (RDs) for each site. However, the RDs will be developed after the preferred alternatives are chosen. The RDs will include descriptions of monitoring programs, performance objectives, land use controls, contingency remedies, etc.[25] Given the uncertainty associated with MNA, the development of effective monitoring programs, performance objectives, and contingency remedies is essential. The Army should make the RDs available for public review and comment as soon as possible.

- The Army intends to review the effectiveness of MNA at each site after two years.[26] These reviews and associated data should be made available for public review and comment.

[24] Shaw, 2009a, page 6-6; Shaw, 2009b, page 7-6; Shaw, 2009c, page 6-7.
[25] US Army, 2010a, pages 13 and 14; US Army, 2010b, page 13; and US Army, 2010c, page 15.
[26] US Army, 2010a, pages 13 and 14; US Army, 2010b, page 13; US Army, 2010c, page 14.

Site-specific Comments

LHAAP-35A(58)

The following comments are based on evaluations of the *Final Proposed Plan for LHAAP-35A(58)*[27]; the *Final Feasibility Study, LHAAP-35A(58)*[28]; and the *Final Modeling Report*[29].

There are two plumes of contaminated groundwater at LHAAP-35A(58): an eastern plume and a western plume.[30] The Army's preferred alternative is Alternative 4. The proposed remedies for the eastern plume are in-situ bioremediation, land use controls (LUCs), and monitored natural attenuation (MNA). The proposed remedies for the western plume are LUCs and MNA.[31] LUCs would be maintained until contaminant concentrations were reduced to acceptable levels [32].

Comments

1. Time for MNA to reduce contaminant concentrations to acceptable levels

    - The proposed plan states that contaminant levels will be reduced to MCLs in approximately 200 years. The uncertainty associated with this estimate is an order of magnitude[33]. That is, the time to achieve MCLs could range from 20 years to 2000 years. It is not reasonable to propose a plan that could require the maintenance of LUCs for many decades or centuries.

2. Effectiveness of MNA

    - In order to rely on MNA as a remedy, the Army should show that natural attenuation is occurring at the site. However, the evidence for natural attenuation at LHAAP-35A(58) is limited. Concentrations of contaminants of concern (COCs) appear to be decreasing in only one monitor well at the site (PCE and 1,1-DCE in well LHSMMW007)[34]. In most cases[35], COC concentrations are either remaining fairly constant or are increasing (PCE and TCE at well LHSMMW004, PCE and TCE at well LHSMMW005, and TCE at well LHSMMW007).[36] The Army should explain why it expects

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[27] US Army, 2010a.
[28] Shaw, 2009a.
[29] Shaw, 2007a.
[30] US Army, 2010a, page 5.
[31] US Army, 2010a, page 8.
[32] US Army, 2010a, page 9.
[33] US Army, 2010a, page 13. An order of magnitude is a factor of ten.
[34] Shaw, 2009a, Appendix A, figures A-3, A-4, and A-6.
[35] Only three wells at LHAAP-35A(58) have been monitored for a sufficient period of time to determine trends in COC concentrations: LHSMMW004, LHSMMW005, and LHSMMW007 (Shaw, 2009a, Appendix A, figures A-4 through A-7).
[36] Shaw, 2009a, Appendix A, figures A-3, A-4, and A-5.

contaminant concentrations to decrease in the future when they are not decreasing in the present.

3. Half-life calculation

- The half-life calculation for 1,1-DCE[37] is not in accord with the EPA's recommendation for performing such calculations. The EPA states that a decrease in contaminant concentration of at least one order of magnitude is necessary in order to reliably calculate a half-life (rate law).[38]

  The half-life calculation for 1,1-DCE is the basis for the Army's estimate that contaminant levels will be reduced to MCLs in approximately 200 years. The Army should either explain why the calculation is appropriate, or it should re-do its estimates for the time required for MNA to reduce contaminant concentrations to acceptable levels at LHAAP-50.

4. Performance objectives and contingency remedy

- The proposed plan states that the progress of MNA will be evaluated for the western plume after two years. If performance objectives for MNA are not being met, a contingency remedy (e.g., bioremediation) will be implemented.[39] The performance objectives will be included in the Remedial Design (RD).[40] However, the RD has not been written. Thus, it is not possible to evaluate suitability of the performance objectives.

- The proposed plan does not mention a contingency remedy for the eastern plume. Given the uncertainty associated with bioremediation[41] and MNA, a contingency remedy should also be developed for the eastern plume.

5. Effect of contaminated groundwater on Goose Prairie Creek

- Groundwater flow directions at LHAAP-35A(58) vary with time. Groundwater at the site may flow to the east, southeast, south, or southwest.[42] However, the Army did not assess the potential effects of

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[37] Shaw, 2009a, Appendix A, figure A-5.
[38] The EPA directive on MNA states: "*As an example, analysis of natural attenuation rates from many sites indicates that a measured decrease in contaminant concentrations of at least one order of magnitude is necessary to determine the appropriate rate law to describe the rate of attenuation, and to demonstrate that the estimated rate is statistically different from zero at a 95% level of confidence (Wilson, 1998). Due to variability resulting from sampling and analysis, as well as plume variability over time, smaller apparent reductions are often insufficient to demonstrate (with 95% level of confidence) that attenuation has in fact occurred at all.*" EPA, 1999, page 21.
[39] US Army, 2010a, page 13.
[40] US Army, 2010a, page 13.
[41] US Army, 2010a, page 11.
[42] US Army, 2010a, page 5; Shaw, 2009a, figures 1-5, 1-6, and 1-7.

contaminated groundwater on the tributary to Goose Prairie Creek that flows about 120 feet from the site's western boundary.[43] Instead, The Army assessed effects of contaminated groundwater on a segment of Goose Prairie Creek that is approximately 6300 feet east of the site.

The Army claims that groundwater will not enter the nearby tributary because the base of the creek channel is above the elevation of the groundwater.[44] However, the elevation of the groundwater will change, both seasonally and over the longer term. Unless the Army can produce the data to show that groundwater levels will not reach the base of the channel, the Army should assess the potential effects of contaminated groundwater on the tributary to Goose Prairie Creek.

- As stated in the General Comments, the model used to simulate contaminant transport, including the transport of groundwater contaminants to Goose Prairie Creek, used some non-conservative assumptions. These assumptions have the effect of reducing the predicted contaminant concentrations in the creek.

6. Extent of groundwater contamination not determined

- The full extent of groundwater contamination at LHAAP-38A(58) has not been determined. Data gaps exist in the following areas: to the south of the western plume between 35AWW06 and 35AWW04; to the southeast of the western plume between 58DPT03 and 35AWW04; to the north of the western plume between 1004TW006 and 58DPT01; to the east of the eastern plume between LHSMW04 and 35AWW07, and to the southeast of the eastern plume between 35AWW01 and LHSMW03.[45] The Army should install at least one monitor well in each of these areas.

LHAAP-46

The following comments are based on evaluations of the *Final Proposed Plan for LHAAP-46*[46]; the *Final Feasibility Study, LHAAP-46*[47]; and the *Final Modeling Report*[48].

There are two plumes of contaminated groundwater at LHAAP-46, one in the shallow zone and one in the intermediate zone.[49] The Army's preferred alternative is Alternative 2. The proposed remedies are land use controls (LUCs), and monitored natural

[43] Shaw, 2007a, Appendix D, page 1-1.
[44] Shaw, 2009a, Appendix A, pages 1-1 and 1-2.
[45] Shaw, 2009a, Appendix A, figure A-3.
[46] US Army, 2010b.
[47] Shaw, 2009b.
[48] Shaw, 2007a.
[49] Shaw, 2009b, page 3-6.

attenuation (MNA).[50] LUCs would be maintained until contaminant concentrations were reduced to acceptable levels[51].

Comments

1. Effectiveness of natural attenuation, increasing contaminant concentrations

    - The Army's predictions of cleanup times (11 to 23 years) are based on data from two wells with decreasing concentrations of TCE.[52] However, in two other wells, one in the shallow zone (LHSMW19) and one in the intermediate zone (46WW02), TCE concentrations are increasing.[53] Although natural attenuation may be occurring in some areas of LHAAP-46, it is clearly not occurring in all areas. The Army should explain why it intends to rely on MNA in areas where contaminant concentrations are increasing.

2. Large areas without monitor wells

    - There are large areas at LHAAP-46 without any monitor wells e.g., the western area between LHSMW15 and 46WW04, the eastern area east of LHSMW24, and the southern area south of LHSMW27.[54] Given the long history of LHAAP, it is not possible to know where all spills or disposal of hazardous materials occurred, whether authorized or unauthorized. No area should be presumed to be uncontaminated. The Army should install monitor wells in all areas of LHAAP-46.

3. Thallium

    - All analyses of thallium in filtered groundwater samples at LHAAP-46 exceeded the MCL.[55] The Army has stated that the thallium is probably naturally occurring.[56] Thus, it is not considered to be a chemical of concern (COC). However, this conclusion does not appear to be supported by the data. First, there is no reliable background data for thallium.[57] Second, the filtered/unfiltered ratios are approximately 1, indicating that that the thallium is dissolved in the groundwater and not associated with suspended sediment.[58] Finally, " … *the consistent thallium/iron ratios … "* that the Army cites as evidence of a natural source do not appear to exist. The thallium/iron ratios vary by more than a factor

[50] US Army, 2010b, page 13.
[51] US Army, 2010b, page 9.
[52] Shaw, 2009b, Appendix A, figure 3-3.
[53] Shaw, 2009b, Appendix A, table 3-3.
[54] Shaw, 2009b, figure 3-1.
[55] Shaw, 2009b, Appendix D, data for September 1997. The MCL for thallium is 2 µg/L (EPA, 2006).
[56] Shaw, 2009b, Appendix B, page 3-8.
[57] Shaw, 2009b, Appendix B, page 3-8.
[58] Shaw, 2009b, Appendix B, page 3-8; Appendix D, table displaying September 1997 data.

of ten[59]. That is not consistent. The Army should perform reliable analyses of background thallium concentrations and re-evaluate it's conclusion regarding the source of thallium. If the Army cannot clearly show that the thallium found at LHAAP-46 is naturally occurring, thallium should be considered a COC.

4. Bis(2-ethyhhexylphthalate)

- Bis(2-ethyhhexylphthalate) was detected in 32 of 83 groundwater samples at LHAAP-46. Concentrations ranged from 0.47 (J)[60] µg/L to 27 µg/L.[61] The MCL is 6 µg/L.[62] The Army does not consider bis(2-ethyhhexylphthalate) to be a COC because: 1) it was detected in a laboratory blank[63], and 2) it is a common laboratory contaminant. However: 1) the blank detection was not associated with the sample that contained the highest concentration of bis(2-ethyhhexylphthalate)[64], and 2) bis(2-ethyhhexylphthalate) is a common component of propellants.[65] Bis(2-ethyhhexylphthalate) should be considered to be a COC at LHAAP-46.

LHAAP-50

The following comments are based on evaluations of the *Final Proposed Plan for LHAAP-50*[66]; the *Final Feasibility Study, LHAAP-50*[67]; and the *Final Modeling Report*[68].

Soils and groundwater are contaminated at LHAAP-50.[69] The Army's preferred alternative is Alternative 2. Under this alternative, the most highly contaminated soils would be excavated and disposed in an off-site facility.[70] Natural attenuation (MNA)[71] 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[72].

[59] Shaw, 2009b, Appendix B, figure 16.
[60] 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.
[61] Jacobs, 2002a, page 8-26.
[62] EPA, 2006.
[63] Shaw, 2009b, page 3-6.
[64] Shaw, 2009b, page 3-6.
[65] ERDC, 2006, table 1. Propellants were used in the industrial operations at LHAAP (Shaw, 2009b, page 1-3).
[66] US Army, 2010c.
[67] Shaw, 2009c.
[68] Shaw, 2007a.
[69] Shaw, 2009c, figures 2-1 through 2-3.
[70] US Army, 2010c, page 10.
[71] Monitored natural attenuation.
[72] US Army, 2010c, page 10.

Comments

1. Time for MNA to reduce contaminant concentrations to acceptable levels

   - The proposed plan states that contaminant levels will be reduced to MCLs in approximately 50 years. The uncertainty associated with this estimate is an order of magnitude[73]. That is, the time to achieve MCLs could range from 5 years to 500 years. It is not reasonable to propose a plan that could require the maintenance of LUCs for many decades or centuries.

2. Unrealistic modeling results

   - The model used to estimate the effects of contaminated groundwater on surface water in Goose Prairie Creek predicts that the concentration of TCE in groundwater next to the creek will be 568 µg/L.[74] The distance from the contaminant source to the creek was assumed to be 132 feet.[75] However, the TCE concentration at well 50WW05, a distance of approximately 250 feet from the contaminant source[76], ranged from approximately 1400 µg/L to 3100 µg/L[77]. In other words, a well approximately twice as far from the source as the distance modeled, is known to have contained far higher concentrations of TCE than was predicted by the model. Clearly, the predictions produced by the model are unrealistic.

3. Extent of groundwater contamination not determined

   - The extent of groundwater contamination in the shallow zone has not been determined. The extent of contamination 1) to the north of Goose Prairie Creek (in the vicinity of 50WW05) [78], and 2) to the east of the former wastewater storage tank (between 50WW02 and 50WW07)[79], is unknown. The Army should install monitor wells in these areas to determine the full extent of groundwater contamination in the shallow zone.[80]

   - The extent of groundwater contamination in the intermediate zone has not been determined. Only one intermediate zone monitor well was installed near LHAAP-50.[81] This well is approximately 250 feet downgradient of the

[73] US Army, 2010c, page 14.
[74] Shaw, 2007a, Appendix J, page 3-1.
[75] Shaw, 2007a, Appendix J, page 2-1.
[76] Shaw, 2009c, figure 2-2.
[77] Shaw, 2009c, appendix A, table 3-2.
[78] Shaw, 2009c, figure 2-2.
[79] Shaw, 2009c, figure 2-2.
[80] At least one well should be installed north of the creek near well 50WW05, and at least one well should be installed between wells 50WW02 and 50WW07 (see Shaw, 2009c, figure 2-2).
[81] Shaw, 2009c, figures 1-4 and 1-5.

contaminant source (former wastewater storage tank). The intermediate zone cannot be adequately characterized with just one well. The Army should install an intermediate zone at or immediately downgradient of the contaminant source. If contaminants are detected in this new well, additional wells should be installed to determine the full extent of contamination in the intermediate zone. If contaminant concentrations exceed standards[82], the Army should develop a plan for remediating the intermediate zone.

4. Depth of soil contamination not determined

- Concentrations of perchlorate in boring 50SB17 increase with depth. Perchlorate concentrations are: non-detect between the surface and a depth of one foot, 740 µg/kg between six and nine feet, and 2600 µg/kg between nine and 11 feet. No samples were taken below 11 feet.[83] The Army should sample soil near 50SB17 all the way down to the water table to determine whether perchlorate at this locations exceeds the TCEQ GWP-Ind limit of 7200 µg/kg. Soils with perchlorate concentrations exceeding this limit should be excavated to protect the underlying groundwater.[84]

5. Surface water monitoring inadequate

- The Army intends to monitor Goose Prairie Creek for perchlorate.[85] However, there is a not-insignificant chance that contaminated groundwater will discharge to the creek. Therefore, the creek should also be monitored for groundwater contaminants (i.e., TCE, cis-1,2-DCE)[86].

- The downstream surface water monitoring location (GPW-1) appears to be too far upstream to be affected by contaminated groundwater.[87] An additional surface water monitor location, in the vicinity of well 50WW05, should be established to determine whether contaminated groundwater is affecting surface water quality.

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[82] See Shaw, 2009c, tables 2-1 and 2-2.
[83] Shaw, 2009c, figure 5-1.
[84] Shaw, 2009c, page 3-4.
[85] Shaw, 2009c, page 5-3.
[86] Shaw, 2009c, page 2-6.
[87] Compare Shaw, 2009c, figures 1-3 and 2-2.

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