IOWA ARMY AMMUNITION PLANT

TECHNICAL MEMORANDUM

SOIL TREATMENT RESULTS FOR ALKALINE HYDROLYSIS IN TRENCH 6 INERT DISPOSAL AREA

for
IOWA ARMY AMMUNITION PLANT
MIDDLETOWN, IOWA

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INTRODUCTION

This technical memorandum documents the treatment approach and analytical results for soil treated by alkaline hydrolysis in Trench 6 at the Inert Disposal Area (IDA) located at the Iowa Army Ammunition Plant (IAAAP). The information contained in this document further supports the continued use of alkaline hydrolysis for treating explosives contaminated soils at the IDA. The approach, rationale, and initial results for alkaline hydrolysis treatment of IDA soils was provided in the *Status Report for Soil Chemical Treatment at the IDA* dated March 2009. Details of the treatment approaches for soil in Trenches 6 and 7 are provided in the *Draft Remedial Action Work Plan for Alkaline Hydrolysis Soil Treatment at the Inert Disposal Area* currently in preparation.

GENERAL REMEDIATION AND SAMPLING APPROACH

Field work for Trench 6 soil treatment was conducted from May 14 to June 09, 2009. To facilitate treatment decisions, Trench 6 was subdivided into 6 decision units (DU) numbered DU1 through DU6 and ranging in volume from 300 cubic yards (cy) to 740 cy each (Figure 1). The total soil treatment volume in Trench 6 is approximately 3,375 cy. The locations and lateral extents of the decision units coincide with those established for biological treatment in 2008. Field work consisted of the following activities:

- Baseline soil sampling
- Amendment with sodium hydroxide
- Mixing
- Field parameter sampling
- Analytical performance sampling

Amendment and Mixing

Chemical amendment was initiated on May 14 and completed on May 22, 2009. Sodium hydroxide was added at the rate of approximately two percent by weight to DUs 1, 2, 3, 4, and 6 and 1.5 percent by weight to DU5. The application rate at DU5 was adjusted lower because DU5 had been previously amended with sodium hydroxide and exhibited an elevated residual pH. The amendment rate equated to approximately 18,000 lbs (9 Super Sacs at 2,000 lbs each) per 350 cy of soil, with a soil density of 100 lbs per ft^3 or 2,700 lbs per cy. The number of supersacs of sodium hydroxide added to each Trench 6 DU is shown in Table 1.

Three successive rounds of mixing were performed after amendment at each DU, from May 14 to May 22, 2009, in order to promote dissolution of the amendment in the soil water phase and contact of the hydroxyl ions with the explosives.

Sampling

Baseline and performance samples were obtained as 20 point/aliquot composite samples for analysis by a contract laboratory using a tracked excavator to limit worker exposure to highly alkaline materials. One composite sample was collected from each 350 cy of soil. Where a DU contained more than 350 cy but less than 700 cy, two composite samples were collected (north and south). One DU (DU6) contained more than 700 cy and three composite samples were collected (north, center and south). Samples for field measurement of soil pH and moisture content were obtained as grab samples using a tracked excavator to limit worker's exposure to highly alkaline materials. Three grab samples (north, center and south) were collected for each DU, regardless of their size.

Due to the time and logistics required to complete each field activity, baseline sampling events, sodium hydroxide amendment, mixing, sampling events for field measurements, and performance sampling events spanned several days across the 6 DUs treated. Baseline sampling events occurred prior to sodium hydroxide amendment between May 14 and 19, 2009 to obtain pre-treatment concentrations. Field measurements for soil pH and moisture content occurred after the second round of mixing between May 18 and 22, 2009 (one to five days after amendment) to assess adequate soil moisture content and mixing effectiveness. The results from this field sampling event were used to determine whether immediate treatment optimization was required (e.g. additional sodium hydroxide addition, irrigation, mixing). Actual treatment efficiency and contaminant destruction were assessed through two rounds of performance sampling. The first performance sampling event occurred between May 29 and 30, 2009 (eight to 15 days after amendment). The second performance sampling event occurred 10 days after the first. Baseline samples and subsequent performance samples were analyzed by a contract laboratory for pH, moisture content, explosives, nitrate and nitrite (Table 2).

Explosives results were evaluated against remedial goals (RG) for individual contaminants as well as the cumulative risk remedial goal at 10^{-6} in accordance with the OU-1 record of decision. Cumulative risk was calculated by comparing concentrations of individual explosives to their corresponding remedial goal at a risk of 10^{-6}. The result of this comparison is a cumulative risk value for each sampling event at each DU or portion thereof (Table 2). The approach for calculating cumulative risk is documented in the OU-1 record of decision as well as the *Draft Remedial Action Work Plan for Alkaline Hydrolysis Soil Treatment at the Inert Disposal Area* currently in preparation.

SPECIFIC REMEDIATION AND SAMPLING RESULTS

The following sections provide a detailed discussion of amendment and sampling results for each Trench 6 DU or sub-unit thereof. The analytical results for each DU/sub-unit are detailed in Table 2. Field pH and moisture results are provided in Table 3.

Decision Unit 1 – DU1

This decision unit contained 640 cy of soil and was therefore divided into two sub-units, referred to as DU1 North and DU1 South. Chemical amendment was performed on May 18, 2009, with a total of 32,000 lbs of sodium hydroxide (16 Super Sacs of 2,000 lbs each) added to the entire soil volume of 640 cy ($1.7x10^6$ lbs), yielding an amendment rate of 1.85% by weight. Three successive rounds of mixing were performed after amendment on May 18, 19, and 20, 2009 in order to promote dissolution of the amendment in the soil water phase and contact of the hydroxyl ions with the explosives.

DU1 North

Baseline Composite Sampling - May 14, 2009
Baseline sampling showed RDX, TNT, and HMX concentrations of 0.494, 1.84 and 2.06 mg/kg, respectively, with other explosive concentrations ranging from non-detect to 0.17 mg/kg. At baseline, all explosive, nitrate, and nitrite concentrations were below their individual RG values. The combined explosive results yielded a human health cumulative risk at baseline of $2.6x10^{-8}$, below the cumulative risk RG of 10^{-6}. The baseline soil pH and moisture content were 6.2 and 21.6%, respectively.

Day 0 - Chemical Amendment – May 18, 2009

Day 1 - Field Grab Sampling - May 19, 2009
Soil pH and moisture content were measured in the field after the second round of mixing and their respective values were 13.4 and 21.7%. Because these values were above the target values of 12.5 and 20%, respectively, further amendment or irrigation was not deemed necessary.

Day 12 - First Performance Composite Sampling - May 30, 2009
The first performance sampling event showed RDX and TNT concentrations were reduced to non-detect, while the HMX concentration was reduced to 1.46 mg/kg. All other explosive concentrations ranged from non-detect to 0.807 mg/kg. All explosive, nitrate, and nitrite concentrations were below their individual RG values. The combined explosive results yielded a human health cumulative risk at Day 12 of $9.4x10^{-9}$, below the cumulative risk RG of 10^{-6}. While Day 12 moisture content at 17.7% was slightly below the target value of 20%, pH at 12.9 was above its respective goal of 12.5. Further amendment or irrigation was not deemed necessary.

Day 22 - Second Performance Composite Sampling - June 9, 2009
The second performance sampling event showed a TNT concentration remaining at non-detect, while the RDX and HMX concentration slightly rebounded to 0.214 and 1.60 mg/kg, respectively. All other explosive concentrations ranged from non-detect levels to 0.398 mg/kg. All explosive, nitrate, and nitrite concentrations remained below their individual RG values. The

combined explosive results yielded a human health cumulative risk at Day 22 of $1.1x10^{-8}$, below the cumulative risk RG of 10^{-6}. While Day 22 pH at 12.4 was slightly below the target value of 12.5, moisture content at 24.8% was above its goal of 20%. Since the cumulative risk was consistently and significantly maintained below the RG of 10^{-6} between Day 12 and 22, and since high residual pH and moisture were observed at Day 22, no further action was taken and the treatment at DU1 North was deemed successful.

DU1 South

Baseline Composite Sampling - May 14, 2009
Baseline sampling showed RDX, TNT, and HMX concentrations of 2.04, 2.80 and 4.51 mg/kg, respectively, with other explosive concentrations ranging from non-detect to 0.716 mg/kg. At baseline, all explosive, nitrate, and nitrite concentrations were below their individual RG values. The combined explosive results yielded a human health cumulative risk at baseline of $6.6x10^{-8}$, below the cumulative risk RG of 10^{-6}. The baseline soil pH and moisture content were 6.3 and 24.9%, respectively.

Day 0 - Chemical Amendment – May 18, 2009

Day 1 - Field Grab Sampling - May 19, 2009
Soil pH and moisture content were measured in the field after the second round of mixing and their respective values were 13.3 and 24.3%. Because these values were above the target values of 12.5 and 20%, respectively, further amendment or irrigation was not deemed necessary.

Day 12 - First Performance Composite Sampling - May 30, 2009
The first performance sampling event showed the TNT concentration was reduced to non-detect, while RDX and HMX concentrations were reduced to 0.0931 and 1.49 mg/kg, respectively. All other explosive concentrations were at non-detect. All explosive, nitrate and nitrite concentrations were below their individual RG values. The combined explosive results yielded a human health cumulative risk at Day 12 of $9.0x10^{-9}$, below the cumulative risk RG of 10^{-6}. Day 12 pH and moisture content at 12.9 and 21.3% were still above the target values of 12.5 and 20%, respectively. Further amendment or irrigation was not deemed necessary.

Day 22 - Second Performance Composite Sampling - June 9, 2009
The second performance sampling event showed TNT remaining at non-detect, while RDX and HMX concentrations rebounded slightly to 0.194 and 2.42 mg/kg, respectively. All other explosive concentrations ranged from non-detect to 0.222 mg/kg. All explosive, nitrate and nitrite concentrations remained below their individual RG values. The combined explosive results yielded a human health cumulative risk at Day 22 of $1.1x10^{-8}$, below the cumulative risk RG of 10^{-6}. Day 22 pH and moisture content at 12.5 and 38.7% were still above the target values of 12.5 and 20.0%, respectively. Since the cumulative human health risk was consistently maintained at a level significantly below the RG of 10^{-6} between Day 12 and 22, and since high residual pH and moisture were observed, no further action was taken and the treatment at DU1 South was deemed successful.

Decision Unit 2 – DU2

This decision unit contained 375 cy of soil and was therefore divided into two sub-units, referred to as DU2 North and DU2 South. Chemical amendment was performed on May 22, 2009, with a total of 20,000 lbs of sodium hydroxide (10 Super Sacs of 2,000 lbs each) added to the entire soil volume of 375 cy ($1.0x10^6$ lbs), yielding an amendment rate of 1.97% by weight. Three successive rounds of mixing were performed after amendment on May 22, 2009 in order to promote dissolution of the amendment in the soil water phase and contact of the hydroxyl ions with the explosives.

DU2 North

Baseline Composite Sampling - May 19, 2009
Baseline sampling showed RDX, TNT, and HMX concentrations of 6.86, 9.83 and 5.63 mg/kg, respectively, with other explosive concentrations ranging from non-detect to 2.78 mg/kg. At baseline, all explosive, nitrate, and nitrite concentrations were below their individual RG values. The combined explosive results yielded a human health cumulative risk at baseline of $2.0x10^{-7}$, below the cumulative risk RG of 10^{-6}. The baseline soil pH and moisture content were 6.7 and 22.9%, respectively.

Day 0 - Chemical Amendment – May 22, 2009

Day 0 - Field Grab Sampling - May 22, 2009
Soil pH and moisture content were measured in the field after the second round of mixing and their respective values were 12.9 and 19.0%. While moisture content was slightly below the target value of 20.0%, pH was above its goal of 12.5%. Further amendment or irrigation was not deemed necessary.

Day 8 - First Performance Composite Sampling - May 30, 2009
The first performance sampling event showed TNT and HMX concentrations were reduced to non-detect, while the RDX concentration was reduced to 0.457 mg/kg. All other explosive concentrations ranged from non-detect to 2.14 mg/kg. All explosive, nitrate, and nitrite concentrations were below their individual RG values. The combined explosive results yielded a human health cumulative risk at Day 8 of $1.6x10^{-8}$, below the cumulative risk RG of 10^{-6}. Day 8 moisture content at 20.1% and pH at 12.9 were above their respective goals of 20.0% and 12.5. Further amendment or irrigation was not deemed necessary.

Day 18 - Second Performance Composite Sampling - June 9, 2009
The second performance sampling event showed a TNT concentration remaining at non-detect, while the RDX and HMX concentration slightly rebounded to 0.725 and 1.61 mg/kg, respectively. All other explosive concentrations ranged from non-detect levels to 0.431 mg/kg. All explosive, nitrate, and nitrite concentrations remained below their individual RG values. The combined explosive results yielded a human health cumulative risk at Day 18 of $2.1x10^{-8}$, below the cumulative risk RG of 10^{-6}. While Day 18 pH at 12.3 was slightly below the target value of 12.5, moisture content at 22.9% was above its goal of 20%. Since the cumulative risk was consistently and significantly maintained below the RG of 10^{-6} between Day 8 and 18, and since

high residual pH and moisture were observed at Day 18, no further action was taken and the treatment at DU2 North was deemed successful.

DU2 South

Baseline Composite Sampling - May 19, 2009
Baseline sampling showed RDX, TNT, and HMX concentrations of 0.690, 46.4 and 5.33 mg/kg, respectively, with other explosive concentrations ranging from non-detect to 7.64 mg/kg. At baseline, all explosive, nitrate, and nitrite concentrations were below their individual RG values. The combined explosive results yielded a human health cumulative risk at baseline of $2.7x10^{-7}$, below the cumulative risk RG of 10^{-6}. The baseline soil pH and moisture content were 6.8 and 22.4%, respectively.

Day 0 - Chemical Amendment – May 22, 2009

Day 0 - Field Grab Sampling - May 22, 2009
Soil pH and moisture content were measured in the field after the second round of mixing and their respective values were 12.8 and 22.3%. Because these values were above the target values of 12.5 and 20%, respectively, further amendment or irrigation was not deemed necessary.

Day 8 - First Performance Composite Sampling - May 30, 2009
The first performance sampling event showed the RDX and TNT concentrations were reduced to non-detect, while HMX concentration was reduced to 1.25 mg/kg. All other explosive concentrations ranged from non-detect to 3.10 mg/kg. All explosive, nitrate and nitrite concentrations were below their individual RG values. The combined explosive results yielded a human health cumulative risk at Day 8 of $1.2x10^{-8}$, below the cumulative risk RG of 10^{-6}. While Day 8 moisture content at 17.2% was slightly below the target value of 20%, pH at 12.8 was above its respective goal of 12.5. Further amendment or irrigation was not deemed necessary.

Day 18 - Second Performance Composite Sampling - June 9, 2009
The second performance sampling event showed RDX and TNT remaining at non-detect, while HMX concentration rebounded slightly to 4.07 mg/kg. All other explosive concentrations ranged from non-detect to 2.19 mg/kg. All explosive, nitrate and nitrite concentrations remained below their individual RG values. The combined explosive results yielded a human health cumulative risk at Day 18 of $9.8x10^{-9}$, below the cumulative risk RG of 10^{-6}. While Day 18 pH at 12.3 was slightly below the target value of 12.5, moisture content at 21.7% was above its goal of 20%. Since the cumulative risk was consistently and significantly maintained below the RG of 10^{-6} between Day 8 and 18, and since high residual pH and moisture were observed at Day 18, no further action was taken and the treatment at DU2 South was deemed successful.

Decision Unit 3 – DU3

This decision unit contained 300 cy of soil and was therefore not divided into sub-units. Chemical amendment was performed on May 22, 2009, with a total of 16,000 lbs of sodium hydroxide (8 Super Sacs of 2,000 lbs each) added to the entire soil volume of 300 cy ($8.1x10^5$ lbs), yielding an amendment rate of 1.97% by weight. Three successive rounds of mixing were performed after amendment on May 22, 2009 in order to promote dissolution of the amendment in the soil water phase and contact of the hydroxyl ions with the explosives.

Baseline Composite Sampling - May 19, 2009
Baseline sampling showed RDX, TNT, and HMX concentrations of 0.196, 147, and 0.556 mg/kg, respectively, with other explosive concentrations ranging from non-detect to 17.1 mg/kg. At baseline, all explosive, nitrate, and nitrite concentrations were below their individual RG values. The combined explosive results yielded a human health cumulative risk at baseline of $7.9x10^{-7}$, below the cumulative risk RG of 10^{-6}. The baseline soil pH and moisture content were 6.9 and 20.1%, respectively.

Day 0 - Chemical Amendment – May 22, 2009

Day 0 - Field Grab Sampling - May 22, 2009
Soil pH and moisture content were measured in the field after the second round of mixing and their respective values ranged from 13.0 to 13.1 and from 17.9 to 20.2%. While moisture content was slightly below the target value of 20.0%, pH was above its goal of 12.5%. Further amendment or irrigation was not deemed necessary.

Day 8 - First Performance Composite Sampling - May 30, 2009
The first performance sampling event showed RDX concentration was reduced to non-detect, while the TNT and HMX concentrations were reduced to 5.20 and 0.500 mg/kg, respectively. All other explosive concentrations ranged from non-detect to 15.1 mg/kg. All explosive, nitrate, and nitrite concentrations were below their individual RG values. The combined explosive results yielded a human health cumulative risk at Day 8 of $4.9x10^{-8}$, below the cumulative risk RG of 10^{-6}. While Day 8 moisture content at 18.0% was slightly below the target value of 20%, pH at 12.9 was above its respective goal of 12.5. Further amendment or irrigation was not deemed necessary.

Day 18 - Second Performance Composite Sampling - June 9, 2009
The second performance sampling event showed RDX and HMX concentrations at non-detect, while the TNT concentration slightly rebounded to 8.38 mg/kg, respectively. All other explosive concentrations ranged from non-detect levels to 1.62 mg/kg. All explosive, nitrate, and nitrite concentrations remained below their individual RG values. The combined explosive results yielded a human health cumulative risk at Day 18 of $6.6x10^{-8}$, below the cumulative risk RG of 10^{-6}. While Day 18 pH at 12.3 was slightly below the target value of 12.5, moisture content at 29.9% was above its goal of 20%. Since the cumulative risk was consistently and significantly maintained below the RG of 10^{-6} between Day 8 and 18, and since high residual pH and moisture were observed at Day 18, no further action was taken and the treatment at DU3 was deemed successful.

Decision Unit 4 – DU4

This decision unit contained 670 cy of soil and was therefore divided into two sub-units, referred to as DU4 North and DU4 South. Chemical amendment was performed on May 17, 2009, with a total of 32,000 lbs of sodium hydroxide (16 Super Sacs of 2,000 lbs each) added to the entire soil volume of 670 cy ($1.8x10^6$ lbs), yielding an amendment rate of 1.77% by weight. Three successive rounds of mixing were performed after amendment on May 17, 18, and 20, 2009 in order to promote dissolution of the amendment in the soil water phase and contact of the hydroxyl ions with the explosives.

DU4 North

Baseline Composite Sampling - May 14, 2009

Baseline sampling showed TNT and HMX concentrations of 1,470 and 3.93 mg/kg, respectively. RDX concentration at baseline was at non-detect. All other explosive concentrations ranged from non-detect to 102 mg/kg. At baseline, all explosive, nitrate, and nitrite concentrations were below their individual RG values, with the exception of TNT, which exceeded its RG of 196 mg/kg. The combined explosive results yielded a human health cumulative risk at baseline of $7.6x10^{-6}$, below the cumulative risk RG of 10^{-6}. The baseline soil pH and moisture content were 6.8 and 26.1%, respectively.

Day 0 - Chemical Amendment – May 17, 2009

Day 1 - Field Grab Sampling - May 18, 2009

Soil pH and moisture content were measured in the field after the second round of mixing and their respective values were 13.3 and 19.6%. While moisture content was slightly below the target value of 20.0%, pH was above its goal of 12.5%. Further amendment or irrigation was not deemed necessary.

Day 12 - First Performance Composite Sampling - May 29, 2009

The first performance sampling event showed HMX concentration was reduced to non-detect, while the TNT concentration was reduced to 0.434 mg/kg. RDX concentration remained at non-detect. All other explosive concentrations ranged from non-detect to 36.1 mg/kg. All explosive, nitrate, and nitrite concentrations were below their individual RG values. The combined explosive results yielded a human health cumulative risk at Day 12 of $2.3x10^{-8}$, below the cumulative risk RG of 10^{-6}. While Day 12 moisture content at 18.3% was slightly below the target value of 20%, pH at 12.7 was above its respective goal of 12.5. Further amendment or irrigation was not deemed necessary.

Day 22 - Second Performance Composite Sampling - June 8, 2009

The second performance sampling event showed RDX and HMX concentrations remaining at non-detect, while the TNT concentration slightly rebounded to 2.31 mg/kg. All other explosive concentrations ranged from non-detect levels to 56.2 mg/kg. All explosive, nitrate, and nitrite concentrations remained below their individual RG values. The combined explosive results yielded a human health cumulative risk at Day 22 of $3.9x10^{-8}$, below the cumulative risk RG of 10^{-6}. While Day 22 pH at 12.4 was slightly below the target value of 12.5, moisture content at 22.9% was above its goal of 20%. Since the cumulative risk was consistently and significantly maintained below the RG of 10^{-6} between Day 12 and 22, and since high residual pH and

moisture were observed at Day 22, no further action was taken and the treatment at DU4 North was deemed successful.

DU4 South

Baseline Composite Sampling - May 14, 2009
Baseline sampling showed a TNT concentration of 1,030 mg/kg. RDX and HMX concentrations at baseline were at non-detect. All other explosive concentrations ranged from non-detect to 135 mg/kg. At baseline, all explosive, nitrate, and nitrite concentrations were below their individual RG values, with the exception of TNT, which exceeded its RG of 196 mg/kg. The combined explosive results yielded a human health cumulative risk at baseline of $5.3x10^{-6}$, below the cumulative risk RG of 10^{-6}. The baseline soil pH and moisture content were 6.9 and 24.8%, respectively.

Day 0 - Chemical Amendment – May 17, 2009

Day 1 - Field Grab Sampling - May 18, 2009
Soil pH and moisture content were measured in the field after the second round of mixing and their respective values were 13.3 and 20.7%. Because these values were above the target values of 12.5 and 20%, respectively, further amendment or irrigation was not deemed necessary.

Day 12 - First Performance Composite Sampling - May 29, 2009
The first performance sampling event showed TNT concentration was reduced to 1.30 mg/kg. RDX and HMX concentrations remained at non-detect. All other explosive concentrations ranged from non-detect to 70.5 mg/kg. All explosive, nitrate, and nitrite concentrations were below their individual RG values. The combined explosive results yielded a human health cumulative risk at Day 12 of $3.9x10^{-8}$, below the cumulative risk RG of 10^{-6}. While Day 12 moisture content at 17.3% was slightly below the target value of 20%, pH at 12.7 was above its respective goal of 12.5. Further amendment or irrigation was not deemed necessary.

Day 22 - Second Performance Composite Sampling - June 8, 2009
The second performance sampling event showed RDX and HMX concentrations remaining at non-detect, while the TNT concentration slightly rebounded to 16.0 mg/kg. All other explosive concentrations ranged from non-detect levels to 31.8 mg/kg. All explosive, nitrate, and nitrite concentrations remained below their individual RG values. The combined explosive results yielded a human health cumulative risk at Day 22 of $1.1x10^{-7}$, below the cumulative risk RG of 10^{-6}. While Day 22 pH at 12.2 was slightly below the target value of 12.5, moisture content at 21.9% was above its goal of 20%. Since the cumulative risk was consistently and significantly maintained below the RG of 10^{-6} between Day 12 and 22, and since high residual pH and moisture were observed at Day 22, no further action was taken and the treatment at DU4 South was deemed successful.

Decision Unit 5 – DU5

This decision unit contained 650 cy of soil and was therefore divided into two sub-units, referred to as DU5 North and DU5 South. Chemical amendment was performed in two phases on May 14 and 16, 2009, with a total of 24,000 lbs of sodium hydroxide (12 Super Sacs of 2,000 lbs each) added to the entire soil volume of 650 cy ($1.7x10^6$ lbs), yielding an amendment rate of 1.37% by weight. A lower amendment rate was selected due to previous amendment at this DU during the alkaline hydrolysis study. Three successive rounds of mixing were performed in order to promote dissolution of the amendment in the soil water phase and contact of the hydroxyl ions with the explosives. The first round was performed in two phases immediately after amendment on May 14 and 16, 2009, while the two consecutive rounds were performed on May 18 and 19, 2009.

DU5 North

Baseline Composite Sampling - May 14, 2009
Baseline sampling showed a TNT concentration of 22.4 mg/kg. RDX and HMX concentrations at baseline were at non-detect. All other explosive concentrations ranged from non-detect to 8.04 mg/kg. At baseline, all explosive, nitrate, and nitrite concentrations were below their individual RG values. The combined explosive results yielded a human health cumulative risk at baseline of $1.6x10^{-7}$, below the cumulative risk RG of 10^{-6}. The baseline soil pH and moisture content were 11.3 and 25.1%, respectively.

Day 0 - Chemical Amendment – May 16, 2009

Day 2 - Field Grab Sampling - May 18, 2009
Soil pH and moisture content were measured in the field after the second round of mixing and their respective values were 13.3 and 22.0%. Because these values were above the target values of 12.5 and 20%, respectively, further amendment or irrigation was not deemed necessary.

Day 13 - First Performance Composite Sampling - May 29, 2009
The first performance sampling event showed TNT concentration was reduced to non-detect, while RDX and HMX concentrations remained at non-detect. All other explosive concentrations ranged from non-detect to 3.43 mg/kg. All explosive, nitrate, and nitrite concentrations were below their individual RG values. The combined explosive results yielded a human health cumulative risk at Day 13 of $1.0x10^{-8}$, below the cumulative risk RG of 10^{-6}. Day 13 moisture content at 22.1% and pH at 12.6 were above their respective goals of 20.0% and 12.5. Further amendment or irrigation was not deemed necessary.

Day 23 - Second Performance Composite Sampling - June 8, 2009
The second performance sampling event showed RDX, TNT and HMX concentrations remaining at non-detect. All other explosive concentrations ranged from non-detect levels to 1.84 mg/kg. All explosive, nitrate, and nitrite concentrations remained below their individual RG values. The combined explosive results yielded a human health cumulative risk at Day 23 of $1.1x10^{-8}$, below the cumulative risk RG of 10^{-6}. While Day 23 pH at 12.3 was slightly below the target value of 12.5, moisture content at 27.3% was above its goal of 20%. Since the cumulative risk was consistently and significantly maintained below the RG of 10^{-6} between Day 13 and 23, and

since high residual pH and moisture were observed at Day 23, no further action was taken and the treatment at DU5 North was deemed successful.

DU5 South

Baseline Composite Sampling - May 14, 2009
Baseline sampling showed a TNT concentration of 485 mg/kg. RDX and HMX concentrations at baseline were at non-detect. All other explosive concentrations ranged from non-detect to 15.8 mg/kg. At baseline, all explosive, nitrate, and nitrite concentrations were below their individual RG values, with the exception of TNT, which exceeded its RG of 196 mg/kg. The combined explosive results yielded a human health cumulative risk at baseline of $2.6x10^{-6}$, below the cumulative risk RG of 10^{-6}. The baseline soil pH and moisture content were 10.2 and 27.1%, respectively.

Day 0 - Chemical Amendment – May 16, 2009

Day 2 - Field Grab Sampling - May 18, 2009
Soil pH and moisture content were measured in the field after the second round of mixing and their respective values were 12.8 and 22.6%. Because these values were above the target values of 12.5 and 20%, respectively, further amendment or irrigation was not deemed necessary.

Day 13 - First Performance Composite Sampling - May 29, 2009
The first performance sampling event showed TNT concentration was reduced to non-detect. RDX and HMX concentrations remained at non-detect. All other explosive concentrations ranged from non-detect to 2.62 mg/kg. All explosive, nitrate, and nitrite concentrations were below their individual RG values. The combined explosive results yielded a human health cumulative risk at Day 13 of $1.1x10^{-8}$, below the cumulative risk RG of 10^{-6}. Day 13 moisture content at 22.9% and pH at 12.5 were equal or above their respective goals of 20.0% and 12.5. Further amendment or irrigation was not deemed necessary.

Day 23 - Second Performance Composite Sampling - June 8, 2009
The second performance sampling event showed RDX and HMX concentrations remaining at non-detect, while the TNT concentration slightly rebounded to 6.40 mg/kg. All other explosive concentrations ranged from non-detect levels to 2.59 mg/kg. All explosive, nitrate, and nitrite concentrations remained below their individual RG values. The combined explosive results yielded a human health cumulative risk at Day 23 of $4.6x10^{-8}$, below the cumulative risk RG of 10^{-6}. While Day 23 pH at 12.1 was slightly below the target value of 12.5, moisture content at 25.5% was above its goal of 20%. Since the cumulative risk was consistently and significantly maintained below the RG of 10^{-6} between Day 13 and 23, and since high residual pH and moisture were observed at Day 23, no further action was taken and the treatment at DU5 South was deemed successful.

Decision Unit 6 – DU6

This decision unit contained 740 cy of soil and was therefore divided into three sub-units, referred to as DU6 North, DU6 Center, and DU6 South. Chemical amendment was performed on May 21, 2009, with a total of 38,000 lbs of sodium hydroxide (19 Super Sacs of 2,000 lbs each) added to the entire soil volume of 740 cy ($2.0x10^6$ lbs), yielding an amendment rate of 1.90% by weight. Three successive rounds of mixing were performed after amendment on May 21, 2009 in order to promote dissolution of the amendment in the soil water phase and contact of the hydroxyl ions with the explosives.

DU6 North

Baseline Composite Sampling - May 16, 2009
Baseline sampling showed RDX and TNT concentrations of 0.546 and 922 mg/kg, respectively. HMX concentration at baseline was at non-detect. All other explosive concentrations ranged from non-detect to 24.9 mg/kg. At baseline, all explosive, nitrate, and nitrite concentrations were below their individual RG values, with the exception of TNT, which exceeded its RG of 196 mg/kg. The combined explosive results yielded a human health cumulative risk at baseline of $4.8x10^{-6}$, below the cumulative risk RG of 10^{-6}. The baseline soil pH and moisture content were 7.6 and 20.0%, respectively.

Day 0 - Chemical Amendment – May 21, 2009

Day 0 - Field Grab Sampling - May 21, 2009
Soil pH and moisture content were measured in the field after the second round of mixing and their respective values were 13.3 and 17.0%. While moisture content was slightly below the target value of 20.0%, pH was above its goal of 12.5%. Further amendment or irrigation was not deemed necessary.

Day 8 - First Performance Composite Sampling - May 29, 2009
The first performance sampling event showed RDX and TNT concentrations were reduced to non-detect, while HMX concentration remained at non-detect. All other explosive concentrations ranged from non-detect to 2.59 mg/kg. All explosive, nitrate, and nitrite concentrations were below their individual RG values. The combined explosive results yielded a human health cumulative risk at Day 8 of $1.2x10^{-8}$, below the cumulative risk RG of 10^{-6}. While Day 8 moisture content at 16.8% was slightly below the target value of 20%, pH at 12.7 was above its respective goal of 12.5. Further amendment or irrigation was not deemed necessary.

Day 18 - Second Performance Composite Sampling - June 8, 2009
The second performance sampling event showed RDX and HMX concentrations remaining at non-detect, while the TNT concentration slightly rebounded to 13.3 mg/kg. All other explosive concentrations ranged from non-detect levels to 1.50 mg/kg. All explosive, nitrate, and nitrite concentrations remained below their individual RG values. The combined explosive results yielded a human health cumulative risk at Day 18 of $8.5x10^{-8}$, below the cumulative risk RG of 10^{-6}. Day 18 moisture content at 21.8% and pH at 12.5 were equal or above their respective goals of 20.0% and 12.5. Since the cumulative risk was consistently and significantly maintained below the RG of 10^{-6} between Day 8 and 18, and since high residual pH and moisture were

observed at Day 18, no further action was taken and the treatment at DU6 North was deemed successful.

DU6 Center

Baseline Composite Sampling - May 16, 2009
Baseline sampling showed a TNT concentration of 329 mg/kg. RDX and HMX concentrations at baseline were at non-detect. All other explosive concentrations ranged from non-detect to 16.2 mg/kg. At baseline, all explosive, nitrate, and nitrite concentrations were below their individual RG values, with the exception of TNT, which exceeded its RG of 196 mg/kg. The combined explosive results yielded a human health cumulative risk at baseline of $1.8x10^{-6}$, below the cumulative risk RG of 10^{-6}. The baseline soil pH and moisture content were 7.6 and 20.3%, respectively.

Day 0 - Chemical Amendment – May 21, 2009

Day 0 - Field Grab Sampling - May 21, 2009
Soil pH and moisture content were measured in the field after the second round of mixing and their respective values were 13.4 and 17.7%. While moisture content was slightly below the target value of 20.0%, pH was above its goal of 12.5%. Further amendment or irrigation was not deemed necessary.

Day 8 - First Performance Composite Sampling - May 29, 2009
The first performance sampling event showed TNT concentration was reduced to non-detect, while RDX and HMX concentrations remained at non-detect. All other explosive concentrations ranged from non-detect to 0.901 mg/kg. All explosive, nitrate, and nitrite concentrations were below their individual RG values. The combined explosive results yielded a human health cumulative risk at Day 8 of $9.4x10^{-9}$, below the cumulative risk RG of 10^{-6}. While Day 8 moisture content at 17.5% was slightly below the target value of 20%, pH at 13.1 was above its respective goal of 12.5. Further amendment or irrigation was not deemed necessary.

Day 18 - Second Performance Composite Sampling - June 8, 2009
The second performance sampling event showed TNT and HMX concentrations remaining at non-detect, while the RDX concentration slightly rebounded to 0.209 mg/kg. All other explosive concentrations ranged from non-detect levels to 2.67 mg/kg. All explosive, nitrate, and nitrite concentrations remained below their individual RG values. The combined explosive results yielded a human health cumulative risk at Day 22 of $1.3x10^{-8}$, below the cumulative risk RG of 10^{-6}. While Day 18 moisture content at 19.5% was slightly below the target value of 20%, pH at 12.5 was equal to its respective goal. Since the cumulative risk was consistently and significantly maintained below the RG of 10^{-6} between Day 8 and 18, and since high residual pH and moisture were observed at Day 18, no further action was taken and the treatment at DU6 Center was deemed successful.

DU6 South

Baseline Composite Sampling - May 16, 2009
Baseline sampling showed RDX and TNT concentrations of 0.446 and 35.4 mg/kg, respectively. HMX concentration at baseline was at non-detect. All other explosive concentrations ranged from non-detect to 6.96 mg/kg. At baseline, all explosive, nitrate, and nitrite concentrations were below their individual RG values. The combined explosive results yielded a human health cumulative risk at baseline of $2.4x10^{-7}$, below the cumulative risk RG of 10^{-6}. The baseline soil pH and moisture content were 7.4 and 20.5%, respectively.

Day 0 - Chemical Amendment – May 21, 2009

Day 0 - Field Grab Sampling - May 21, 2009
Soil pH and moisture content were measured in the field after the second round of mixing and their respective values were 13.4 and 15.7%. While moisture content was slightly below the target value of 20.0%, pH was above its goal of 12.5%. Further amendment or irrigation was not deemed necessary.

Day 8 - First Performance Composite Sampling - May 29, 2009
The first performance sampling event showed RDX and TNT concentrations were reduced to non-detect, while HMX concentration remained at non-detect. All other explosive concentrations ranged from non-detect to 2.46 mg/kg. All explosive, nitrate, and nitrite concentrations were below their individual RG values. The combined explosive results yielded a human health cumulative risk at Day 8 of $1.2x10^{-8}$, below the cumulative risk RG of 10^{-6}. While Day 8 moisture content at 17.2% was slightly below the target value of 20%, pH at 12.7 was above its respective goal of 12.5. Further amendment or irrigation was not deemed necessary.

Day 18 - Second Performance Composite Sampling - June 8, 2009
The second performance sampling event showed RDX, TNT and HMX concentrations remaining at non-detect. All other explosive concentrations ranged from non-detect levels to 3.48 mg/kg. All explosive, nitrate, and nitrite concentrations remained below their individual RG values. The combined explosive results yielded a human health cumulative risk at Day 18 of $1.2x10^{-8}$, below the cumulative risk RG of 10^{-6}. While Day 18 pH at 12.3 was slightly below the target value of 12.5, moisture content at 22.7% was above its goal of 20%. Since the cumulative risk was consistently and significantly maintained below the RG of 10^{-6} between Day 8 and 18, and since high residual pH and moisture were observed at Day 18, no further action was taken and the treatment at DU6 South was deemed successful.

Conclusions

The concentration data and associated cumulative risk values shown in Table 2 demonstrate rapid and substantial reductions in explosives concentrations and human health risk from the alkaline hydrolysis treatment process. All explosives, nitrate, and nitrite were less than their individual RGs at the second performance sampling event. Results from the second performance sampling also show the cumulative human health risk RG of 10E-06 has been achieved at all DUs with cumulative risk values ranging from 10E-07 to 10E-09.

Recommendations

Additional soil treatment should proceed in Trench 7 using the alkaline hydrolysis method to remediate the remaining explosive-contaminated soils. This recommendation is supported by the successful implementation of alkaline hydrolysis treatment in Trench 6, where moderate to high explosives concentrations were reduced substantially below the cumulative risk remedial goal in less than 10 days. The sodium hydroxide application rate (i.e. the amount of sodium hydroxide applied to each DU) should be reduced from that used in Trench 6. The amendment rate should be reduced because of the quick and substantial reduction in explosives concentrations observed in Trench 6. The speed and magnitude of explosives reduction suggests that the amendment rate can be lowered. The rate of adjustment is a decision made based on a combination of the theoretical production of hydroxyl ions and field application experience. Three amendment rates (<1%, 1%, and 1.5%) will be tried in Trench 7 to determine an optimal rate for future applications. Reducing the sodium hydroxide application rate will optimize raising the pH to the target level necessary to remediate explosives without overdosing the soil and creating excessive pH conditions. Excessive pH in the soil could lead to high pH in the Trench 7 pool water which would then require pH modification so that the IDA fixed facility water treatment plant discharge remains in compliance. The National Pollutant Discharge Elimination System (NPDES) pH limit for discharge at IAAAP is 9 standard units. This is the upper pH limit that will be used for discharge from the fixed facility water treatment plant at the IDA.

Progress soil samples should be collected from each treatment DU approximately 5 days after mixing has been completed. EPA Method 8330A should be used to analyze soil samples on a quick turnaround time basis of 7 days to expeditiously determine treatment progress. EPA Method 8330B was used to assess the progress of soil treatment in Trench 6 but requires at least 21 days to receive results and therefore does not provide timely data for remedial decision making. An accelerated schedule within which remedial/treatment decisions can be made is desirable to capitalize on warm weather conditions in the summer because the treatment method is temperature dependent. Treatment is not possible during the colder months at IAAAP from late fall through winter and early spring. The accelerated schedule is also necessary to avoid water treatment capacity and treatment issues in Trench 6. Because the holding capacity of Trench 6 has been and will continue to be reduced by the addition of soil from Trench 7 and other sources, there is a potential for uncontrolled releases over the winter and early spring due to high precipitation coupled with the diminished capacity. If Trench 7 soil is remediated this summer, then Trench 7 can be removed and Trench 6 capped prior to the winter, therein reducing the potential for uncontrolled releases.

TABLES

Table 1: Trench 6 Treatment Characteristics by Decision Unit

Full-Scale Alkaline Hydrolysis Soil Treatment
Inert Disposal Area
Iowa Army Ammunition Plant, Middletown, Iowa

Decision Unit	Volume (cy)	# of Composite Samples per Round (Round 1, 3 and 4)	# of 2,000 lbs Super-Sacs of Sodium Hydroxide
1	640	2	16
2	375	2	10
3	300	1	8
4	670	2	16
5	650	2	12
6	740	3	19
Total	3,375	12	81

Table 2: Trench 6 Analytical Results

Full-Scale Alkaline Hydrolysis Soil Treatment
Inert Disposal Area
Iowa Army Ammunition Plant, Middletown, Iowa

Decision Unit	Area	Days	RDX (mg/kg)	MNX (mg/kg)	DNX (mg/kg)	TNX (mg/kg)	TNT (mg/kg)	2-A-4,6-DNT (mg/kg)	4-A-2,6-DNT (mg/kg)	1,3,5-TNB (mg/kg)	3,5-Dinitroaniline (mg/kg)	HMX (mg/kg)	Nitrate (mg/kg)	Nitrite (mg/kg)	Moisture Content (%)	pH (SU)	Health Cumulative Risk
Remedial Goals[a]			**53**	**53**	**53**	**53**	**196**	**4,088**	**4,088**	**102**	**4,088**	**51,000**	**1,600,000**	**100,000**	--	--	--
1	North	Baseline	0.494	ND	ND	ND	1.84	0.166	0.127	0.134	ND	2.06	1.8	ND	21.6	6.2	2.6E-08
1	North	12	ND	ND	ND	ND	ND	0.0856	0.807	ND	0.357	1.46	0.73	2.9	17.7	12.9	9.4E-09
1	North	22	0.214	ND	ND	ND	ND	0.142	0.398	ND	0.0417	1.60	1.1	3.1	24.8	12.4	**1.1E-08**
1	South	Baseline	2.04	0.209	ND	ND	2.80	0.716	0.447	0.481	0.133	4.51	ND	ND	24.9	6.3	6.6E-08
1	South	12	0.0931	ND	ND	ND	ND	ND	ND	ND	ND	1.49	0.76	5.1	21.3	12.9	9.0E-09
1	South	22	0.194	ND	ND	ND	ND	0.0532	0.222	ND	ND	2.42	1.5	5.6	38.7	12.5	**1.1E-08**
2	North	Baseline	6.86	0.458	ND	ND	9.83	2.78	2.08	0.200	0.0831	5.63	ND	ND	22.9	6.7	2.0E-07
2	North	8	0.457	ND	ND	ND	ND	0.360	2.14	0.0900	0.152	ND	1.1	3.6	20.1	12.9	1.6E-08
2	North	18	0.725	ND	ND	ND	ND	0.167	0.431	ND	0.0707	1.61	1.2	4.9	22.9	12.3	**2.1E-08**
2	South	Baseline	0.690	ND	ND	ND	46.4	7.64	7.57	0.899	0.550	5.33	1.3	ND	22.4	6.8	2.7E-07
2	South	8	ND	ND	ND	ND	ND	0.576	3.10	0.293	0.244	1.25	1.8	13.4	17.2	12.8	1.2E-08
2	South	18	ND	ND	ND	ND	ND	0.854	2.19	0.0896	0.176	4.07	1.3	9.6	21.7	12.3	**9.8E-09**
3	N/A	Baseline	0.196	ND	ND	ND	147	16.4	17.1	2.17	0.932	0.556	1.4	ND	20.1	6.9	7.9E-07
3	N/A	8	ND	ND	ND	ND	5.20	5.69	15.1	0.989	0.379	0.500	6.6	50.2	18.0	12.9	4.9E-08
3	N/A	18	ND	ND	ND	ND	8.38	ND	ND	1.62	ND	ND	2.1	42.2	29.9	12.3	**6.6E-08**
4	North	Baseline	ND	ND	ND	ND	1470	86.1	102	3.20	2.95	3.93	ND	2.2	26.1	6.8	7.6E-06
4	North	12	ND	ND	ND	ND	0.434	14.9	36.1	ND	ND	ND	1.5	31.1	18.3	12.7	2.3E-08
4	North	22	ND	ND	ND	ND	2.31	18.5	56.2	ND	ND	ND	2.1	50.2	22.9	12.4	**3.9E-08**
4	South	Baseline	ND	ND	ND	ND	1030	95.5	135	ND	ND	ND	ND	1.7	24.8	6.9	5.3E-06
4	South	12	ND	ND	ND	ND	1.30	25.6	70.5	ND	ND	ND	2.2	32.5	17.3	12.7	3.9E-08
4	South	22	ND	ND	ND	ND	16.0	31.8	ND	1.47	ND	ND	2.3	61.7	21.9	12.2	**1.1E-07**
5	North	Baseline	ND	ND	ND	ND	22.4	5.28	8.04	3.93	0.760	ND	3.4	27.1	25.1	11.3	1.6E-07
5	North	13	ND	ND	ND	ND	ND	0.325	3.43	0.133	0.147	ND	3.2	59.1	22.1	12.6	1.0E-08
5	North	23	ND	ND	ND	ND	ND	0.444	1.84	0.248	0.217	ND	4.5	63.7	27.3	12.3	**1.1E-08**
5	South	Baseline	ND	ND	ND	ND	485	6.86	3.70	15.8	0.612	ND	7.0	40.6	27.1	10.2	2.6E-06
5	South	13	ND	ND	ND	ND	ND	0.673	2.62	0.194	ND	ND	9.6	87.7	22.9	12.5	1.1E-08
5	South	23	ND	ND	ND	ND	6.40	0.807	2.59	0.457	0.356	ND	8.4	100	25.5	12.1	**4.6E-08**
6	North	Baseline	0.546	ND	ND	ND	922	24.9	7.15	11.2	0.431	ND	15.3	3.4	20.0	7.6	4.8E-06
6	North	8	ND	ND	ND	ND	ND	0.468	2.59	0.365	0.155	ND	21.3	59.2	16.8	12.7	1.2E-08
6	North	18	ND	ND	ND	ND	13.3	1.16	1.50	0.943	0.226	ND	9.8	58.7	21.8	12.5	**8.5E-08**
6	Center	Baseline	ND	ND	ND	ND	329	7.86	4.57	16.2	0.722	ND	16.6	2.9	20.3	7.6	1.8E-06
6	Center	8	ND	ND	ND	ND	ND	0.151	0.901	0.112	0.0491	ND	3.3	22.4	17.5	13.1	9.4E-09
6	Center	18	0.209	ND	ND	ND	ND	0.612	2.67	0.243	0.211	ND	7.9	44.0	19.5	12.5	**1.3E-08**
6	South	Baseline	0.446	ND	ND	ND	35.4	6.96	5.76	4.16	0.335	ND	16.0	1.3	20.5	7.4	2.4E-07
6	South	8	ND	ND	ND	ND	ND	0.523	2.46	0.317	0.262	ND	14.2	14.3	17.2	12.7	1.2E-08
6	South	18	ND	ND	ND	ND	ND	0.846	3.48	0.319	0.329	ND	11.8	22.0	22.7	12.3	**1.2E-08**

[a] Remedial goals are from OU-1 ROD except where noted below:
2-A-4,6-Dinitrotoluene and 4-A-2,6-Dinitrotoluene PRGs were calculated based on current toxicity values and OU-1 ROD exposure parameters.
Nitrate and nitrite are from the 2008 EPA RSL table.
Surrogate for MNX, DNX, TNX is RDX at 53 mg/kg
Surrogate for 3,5-Dinitroaniline is 2-A-4,6-Dinitrotoluene at 4,088 mg/kg

SU Standard Units
N/A Not applicable
ND Non-detect

Table 3: Trench 6 Field Results

Full-Scale Alkaline Hydrolysis Soil Treatment
Inert Disposal Area
Iowa Army Ammunition Plant, Middletown, Iowa

Decision Unit	Area	Days	Moisture Content (%)	pH (SU)
1	North	1	21.7	13.4
1	Center	1	22.8	13.3
1	South	1	24.3	13.3
2	North	0	19.0	12.9
2	Center	0	23.0	12.8
2	South	0	22.3	12.8
3	North	0	19.4	13.1
3	Center	0	17.9	13.0
3	South	0	20.2	13.0
4	North	1	19.6	13.3
4	Center	1	22.0	13.4
4	South	1	20.7	13.3
5	North	2	22.0	13.3
5	Center	2	24.6	13.4
5	South	2	22.6	12.8
6	North	0	17.0	13.3
6	Center	0	17.7	13.4
6	South	0	15.7	13.4

SU Standard Units

FIGURES

CONSTRUCTION ENTRANCE

EQUIPMENT DECONTAMINATION AREA

TRENCH 7

TRENCH 6

Du1

Du2

Du3

Du4

Du5

Du6

T-4

T-9

ET1

ET2

GP-3

CAMU-99-1D

CAMU-99-1S

IDA-MW1

JAW-28

C-00-3

TRENCH 6 BOUNDARY

TOP EDGE OF TRENCH 6 AS-BUILT (APPROX)

WOODS

SP

GRAVEL ROAD

212 211 210 213 214 215 216 217 206 208 209

N

METERS 0 9 18 27 36

FEET 0 30 60 90 120

CAD FILENAME:
K:\DGN\IAAP\Sites\Inert Disp Area\IDA-066.dgn
DATE: 6-29-09
SOURCE: Base map from 1998 Baker plant-wide survey and May 2005 Martin & Whitacre topographic survey.

ALL COORDINATES ARE ON THE IOWA STATE PLANE COORDINATE SYSTEM, SOUTH ZONE IN METERS BASED ON THE NAD83 ADJUSTMENT OF 1996. THE VERTICAL CONTROL REFERENCE DATUM IS NAVD88.

TECHNICAL MEMORANDUM
ALKALINE HYDROLYSIS
SOIL TREATMENT AT TRENCH 6
IOWA ARMY AMMUNITION PLANT
MIDDLETOWN, IOWA

LEGEND

Du1 — SOIL TREATMENT DECISION UNIT 1

GP-3 — MONITORING WELL

211 — GROUND SURFACE CONTOUR (1 METER INTERVAL)

GROUND SURFACE CONTOUR (0.25 METER INTERVAL)

EXISTING ROAD

TETRA TECH
OAK RIDGE, TENNESSEE

FIGURE 1
DECISION UNITS 1-6 LAYOUT
TRENCH 6
INERT DISPOSAL AREA