N00221_003493
MARE ISLAND
SSIC NO. 5090.3.A

Tetra Tech FW, Inc.
Mare Island Former Marine Corps Firing Range

TREATABILITY REPORT
Phase III
N68711-98-D-5713

T. E. Moody, Ph.D
Metals Treatment Technologies, LLC
July 13, 2004

1.0 OBJECTIVE

The objective of this report is to present the findings of a laboratory treatability study conducted by MT^2 designed to determine the concentrations of lead (Pb) extracted and analyzed by STLC (Cal Wet Na-citrate) and TCLP methods after stabilization by CaO and Portland cement. Amendments were added to the soil in an effort to stabilize or chemically convert the Pb to concentrations acceptable by regulatory criteria.

2.0 SAMPLE DESCRIPTION and CHARACTERIZATION

The phase III Treatability Study builds on the characteristics and reactivity of a Pb contaminated soil from the area described as "Sample #3." Initially, 5 samples were shipped to MT^2 for XRF determination of Pb. These samples were designated "Sample 1, 2, 3, 4 and 5." These samples were received and logged by MT^2 on May 28, 2004 at ~11:00AM. XRF analysis was completed at 12:30PM, May 28, 2004. The initial XRF characterization data for determining which samples would be hazardous for Pb are presented in Table 1. Readings were made with a Niton XL 700 multi-element XRF spectrophotometer. Readings were determined in the bulk mode after executing the internal calibration. Sufficient readings are determined at 30 seconds; the longer the reading the more accurate the determination, and the lower the detection limits. These readings were made ~ 60 sec. Two readings were taken on each bag: one reading on the front and one reading on the back.

Table 1. Preliminary XRF Pb Determinations for Samples 1, 2, 3, 4 and 5

I.D.	XRF #	Time	Pb, mg/kg	Pb, average
Sample 1	117	60 sec	206	163
	118	60 sec	120	
Sample 2	119	60 sec	307	256
	120	60 sec	205	
Sample 3	121	60sec	**639**	**581**
	122	60 sec	**523**	
Sample 4	123	60 sec	188	274
	124	60 sec	360	
Sample 5	125	60 sec	311	321
	127	60 sec	330	

It was directed by Tetra Tech FW that Sample #3 would be used in the treatability study. This soil exhibited the highest total Pb concentration. Two 5-gallon pails were shipped to MT^2 shortly after. One pail contained Sample #3, the other contained Sample #5. Sample #3 was confirmed as the soil to use June 8, 2004 and was labeled as MT^2 130-5. The sample was physically examined and determined to contain fragments of firing range shot material. Before proceeding to stabilization, sample MT^2 130-5 was tested for TCLP Pb, STLC Pb, TTLC Pb, moisture content, grain size, and Atterberg limits.

The soil was then tested for hazardous Pb by using EPA's SW-846 Method No. 1311 "Toxicity Characteristic Leaching Procedure" (TCLP) and the STLC (Cal WET Na-citrate) procedure. The TCLP and STLC extraction fluids were then filtered and analyzed by atomic absorption spectrophotometry. These analyses were done in-house by MT^2. The atomic absorption Pb analysis was implemented using a Perkin-Elmer model 5100 atomic absorption spectrophotometer. The TTLC analysis was performed by Evergreen Laboratories, Wheat Ridge, Colorado. The TCLP data in Table 2 indicates that the sample was not RCRA hazardous with respect to leachable Pb. However, the STLC analysis indicates that the sample is a California Hazardous Waste.

Table 2. Pre-treatment TCLP, STLC and TTLC Data

MT^2 Sample #	Client ID#	XRF Pb mg/kg	TTLC Pb mg/kg	TCLP Pb mg/l	STLC Pb mg/l
130-5	Sample #3	581	950	0.8	72.2
RCRA Criteria				**5.0**	
STLC Criteria					**5.0**

3.0 GEOPHYSICAL TESTING

Per requirements in the Phase III SOW, sample 130-5 was sent to Goodson & Associates, Denver, CO, for moisture, grain size, and Atterberg limit analysis. The pH was done in house at MT^2 laboratories, Wheat Ridge, CO. The physical parameters were client requested, and as such, will not be discussed from a chemical stabilization standpoint. The original data report was scanned and included at the end of this report as Table 8. Table 3 is a summary of the original data reports.

Table 3. Geophysical Testing Data

Sample # 3 (MT^2 130-5)	
pH	7.3
Moisture content	26.0% (Determination by MT^2 is 24.0%)
Grain size	% Silt & % Clay: 86.6%; % Sand: 2.5%; % Gravel: 10.9%
Soil Type	Elastic Silt
Atterberg limits	LL: 71 PI: 36

4.0 TREATMENT STUDIES

4.1 Technical Premise

Two stabilization treatment regimes were indicated in the agreed upon SOW, May 21, 2004. Those stabilizing agents to be used are quicklime (CaO) supplied by Chemical Lime Company, Fort Worth, Texas and Portland cement, Type II, supplied by MT^2. Two sizing grades of CaO were shipped to MT^2 for consideration. The larger size particle was 3/8" by 1/8" and the smaller size was –1/8". The smaller –1/8" size was used because of the increased surface area and greater reactivity.

The quicklime treatment (CaO) is utilized to precipitate Pb as the hydroxide and stabilize the sample to below the STLC Pb and TCLP Pb criteria of 5 mg/l. The Portland cement treatment regimen stabilizes by pH (the hydroxide formation), and by physical encapsulation. These two treatment chemistries (at similar concentrations) were selected for the phase III project to stabilize Pb for leachability determined by TCLP and STLC procedures.

4.2 Procedure For Treatment Studies

Sample #3 (as designated by the client) was used for treatment studies in an attempt to stabilize or chemically convert the Pb to non-leachable forms. The sample was first homogenized by dumping the 5-gallon pail onto a large sheet of butcher paper. The soil was then rolled back and forth in opposite directions. Large clumps were broken up and the composite was again rolled back and forth. Material greater than 3/8" was removed by screening (dictated by TCLP procedure). Protective gloves and safety glasses were worn during the compositing procedure. Each treatment was implemented using 150g of the contaminated soil. As with the untreated data, the treated soil was examined for irregularities. A few Pb bullets, fragments, casings and/or solid Pb metal fragments were discovered. Treatment formulas were applied and mixed with the sample in increasing amounts. From Table 3, the moisture content for Sample #3 (MT^2 130-5) is ~ 25.0%. However, the inherent moisture in the soil does not effect dissolution of either the CaO or the Portland cement as much as water that is added. Additional water must be added to induce the desired chemistry. The CaO treatment concentrations range from 5% to 15% by weight basis. The Portland cement treatment concentrations is also the same range, from 5% to 15% by weight basis. Of the two treatment regimes, the CaO addition appears to be the most sensitive to the water addition. This assumption is made from previous work at MT^2, and from the two

previous treatability studies done under this contract. After weighing measurements and complete mixing with the treatment materials, the sample and treatment materials were allowed to incubate and stabilize for 72 hours. Following the incubation period, an aliquot of each treatment sample was extracted and analyzed for Pb implementing EPA's SW-846 Method No. 1311 "Toxicity Characteristic Leaching Procedure" (TCLP) and the Cal WET Na-citrate procedure (STLC). The TCLP and STLC extraction fluids were then filtered and analyzed by atomic absorption spectrophotometry. These analyses were done in-house by MT^2. The atomic absorption Pb analysis was implemented using a Perkin-Elmer model 5100 atomic absorption spectrophotometer. The results of the TCLP and STLC extraction and Pb analysis are presented in Table 4.

5.0 DISCUSSION

5.1 TCLP Pb Data

From Table 4, Sample #3, MT^2 130-5, was not found to be hazardous by RCRA standards. However, the sample is above the STLC regulatory limit of 5 mg/l Pb and is considered a California hazardous waste. Thus, the stabilizing materials will be added to reduce the STLC extractable Pb to acceptable levels. However, the induced alkalinity by the addition of either CaO or the type II Portland cement raises the TCLP Pb concentration to hazardous levels. Therefore the functionality of either stabilizing chemical must be controlled by facilitating the right amount of chemical to reduce the STLC Pb while not allowing the TCLP Pb to increase to hazardous levels. The lowest concentration of CaO (5%) appears to be the only concentration that induces a hazardous TCLP concentration (test 12-64-7). And this concentration also results in one of the highest STLC Pb levels. All of the other CaO amendment concentrations appear to keep the TCLP Pb concentration in check. For the type II Portland cement additions, the same increase in TCLP Pb is observed. The 5% amendment of cement appears to give the highest combination of TCLP and STLC Pb levels (test 12-64-10). Although there are some anomalies, the higher concentrations appear to reduce the TCLP Pb the same as CaO. Thus finding the right formula for reducing STLC Pb while not increasing TCLP Pb is paramount to success.

5.2 STLC Pb Data

The STLC extraction and analysis procedure continues to be a challenge for stabilization technologies. Theories of altering chelate chemistries and the actual application are presented in the phase I treatability study (submitted to Tetra Tech FW, 02/13/04). The citrate compound is such an effective chelator for metals (Pb included) that many stabilization chemistries are ineffective. For the phase III project, both CaO and Portland cement are effective in reducing the STLC Pb to below the 5 mg/l level. The mode of action is not clearly understood, but it is suggested that within a certain pH regime, the Pb hydroxide complex occurs and, by mass action, the citrate chelation of Pb is reduced. Table 4 lists the various CaO and Portland cement levels that reduce the STLC Pb to below 5 mg/l while not significantly increasing the TCLP Pb to hazardous levels. It does appear that that the type II Portland cement amendment is more effective in reducing the STLC Pb while not increasing the TCLP Pb levels. This will be confirmed in the next section.

5.3 Reproducibility and Consistent Stabilizing Chemistry

It is beyond the scope of this project to detail and describe the chemistries that constitute the anomalies that occur in using CaO or Portland cement to stabilize hazardous metals. But what can be said is that finding the correct combination of CaO/water or Portland cement/water is critical. Too little water, the chemical doesn't dissociate, and the desired alkaline pH is not achieved. Too much water, and the alkalinity is to high and the buffering for long term stabilization is eliminated. For this project, varying amounts of water were added to both CaO and Portland cement formulations to observe the effect in reducing the STLC Pb and TCLP Pb. From Table 4, two formulas of CaO were successful in reducing the STLC Pb and TCLP Pb. These formulas were 8.5%/15.7% water and 12.5%/18% water. Three formulas of Portland cement were also successful in reducing the STLC Pb and TCLP Pb. The Portland cement formulas were 10%/10% water, 10%/16.7% water and 13%/19% water. All five of these formulations were duplicated, allowed to incubate for 72 hours, and then extracted and analyzed. The duplicates are indicated by the letter D in the client ID column. The results in Table 4 indicate that only one of the CaO formulas was reproducible. The 8.5%CaO/15.7% water formula was the reproducible formula (tests 12-64-14 and 12-67-1). The formulas consisting of Portland cement were much more consistent and reproducible. The Portland cement formulas consisting of 10% cement/10% water and 10% cement and 16.7% water were reproducible (tests 12-64-18, 12-67-3 and 12-64-19R, 12-67-4). A third formula, 13%/19% water was outside reproducibility by only 1 mg/l (tests 12-64-16 and 12-67-5).

5.4 Extended Cure/Incubation Time

It is invaluable to have a stabilization chemistry that is robust and stands the test of time. As a requirement in the SOW, CaO and $Ca(OH)_2$ stabilized samples from the Phase II project were extracted and analyzed for STLC and TCLP Pb after an approximate two month incubation time. These results are presented in Table 5. The CaO (supplied from Mid River Minerals) and the $Ca(OH)_2$ (supplied from Chemical Lime) formulations did not reduce the STLC Pb or the TCLP Pb to below 5mg/l in the initial Phase II study. The STLC Pb results indicate that the CaO stabilization at the 7.5 and 10% additive rates is stable over the 2 month incubation time. However, the TCLP Pb results for the same chemical and rates indicate that the longer incubation time is preferred. The TCLP Pb is drastically reduced to below the regulatory limit of 5 mg/l Pb (tests 12-51-3 and 12-51-4). For the $Ca(OH)_2$ stabilizing amendment, the STLC Pb data is spurious, and indicates instability during the two months. The TCLP Pb data (tests 12-51-7 and 12-51-8) are reduced to significant levels in the two month period. Test 12-51-8 indicates that after 2 months the TCLP Pb is non-hazardous. From the data, the precipitation of Pb as the hydroxide is still occurring. Although a positive trend, the stabilization is unstable. Without other forms of experimentation and analysis of the exact nature for these anomalies is difficult to determine.

A more confirming study regarding differences in incubation times was executed with the Phase III stabilized samples. The data is presented in Table 6. The duplicate samples discussed in section 5.3 were sampled again after 216 hours (9 days) incubation time. The CaO formula consisting of 8.5% CaO/ 15.7% water indicated stability during this incubation time, with STLC

Pb and TCLP Pb concentrations being substantially below the 5 mg/l regulatory limit (test 12-67-1). The Portland cement formulas also indicated a stability during the 216 hour incubation time. The STLC Pb and TCLP Pb concentrations resulting from the 10%/10% water Portland cement formulation were substantially below the 5 mg/l Pb regulatory limit (test 12-67-3). Then 10%/16.7% water cement stabilization indicated slight instability with an increase in the STLC Pb (test 12-64-4). However, this was only an increase of 1.7 mg/l (ppm) above the regulatory limit of 5.0 mg/l and can be paralleled to field variability.

5.5 Physical Observations of Pre- and Post-Stabilization

Soils used in the Phase III study were homogenized on the Mare Island site by the use of a trommel. As received, Sample #3 was pliable and easy to work. From a field application standpoint, a major concern is the hardening effect of the stabilizing chemicals. In Phase III, the highest added concentrations of CaO and water did bulk the soil volume but did not form aggregate clumps. The highest concentrations of the Portland cement treatment did induce aggregate clumping, but not of a solid cement-like nature (test 12-64-12). Before taking aliquots for TCLP and STLC extraction and analysis, the soft aggregate clumps could be broken by finger pressure. The treated soils in tests 12-64-18 and 12-67-3 were examined for physical differences resulting from the stabilizing amendment. These tests were 10% Portland cement additions. The aggregate clumping was substantially less than test 12-62-12, and very little noticeable difference over the untreated soil.

5.6 Volume Increase Relative to Treatment

Many stabilizing amendments are known to increase the volume of the stabilized media by more than just the additive mass amount of the amendment. Lime and cement are two such stabilizing materials. This is commonly referred to as the bulking factor. Presented in Table 6 are the data representing the volume increases of five CaO and Portland cement formulations. Three of the five formulations presented were successful in stabilizing Pb to below the STLC and TCLP regulatory limits. The volume increases are presented on a normal water content after stabilization basis and on a 24 hour air dried room temperature basis.

6.0 CONCLUSIONS

a) Sample #3, MT^2 130-5, was analyzed and found not be hazardous by RCRA standards. However, by STLC analysis, the soil is considered a California Haz-Waste.

b) The quicklime CaO (supplied from Chemical Lime) stabilizing treatments using 8.5 and 12.5% did reduce the TCLP Pb to non-hazardous levels and did reduce the STLC Pb to below California Haz-Waste regulatory limits.

c) The Portland cement (Type II) stabilizing treatments using 10 and 13% reduced the TCLP Pb to non-hazardous levels and did reduce the STLC Pb to below California Haz-Waste regulatory limits.

d) The Portland cement (Type II) stabilizing treatments were the most consistent, reproducible and stable.

e) The increase in volume (with treatment) above that of proportional increase appears to be greatest with the CaO treatment regime. Of the two CaO treatments that were successful in meeting STLC Pb and TCLP Pb regulatory criteria, the volume increase (upon treatment) were 12.7% and 7.0% for the CaO treatment. The Portland cement treatment (for the same success) increased volume by 5.9% and 9.9%.

f) The Portland cement (type II) stabilizing treatment of 10% Portland cement/10% water appears to be the most efficient at stabilizing Pb to below the TCLP and STLC regulatory requirements.

Table 4. TCLP Pb and STLC Pb Extraction and Analysis

Test Number	Client ID	CaO %	Portland Cement %	H_2O %	pH: soil + amend	pH: STLC filtrate	pH: TCLP filtrate	TTLC Pb mg/kg	TCLP Pb mg/l	STLC Pb mg/l
Controls/ Untreated										
12-64-5	#3				7.3		5.1	950	.76	
12-64-6	#3					5.1				72.2
Treatments										
12-64-7	#3	5		13.3	11.9	6.5	4.9		7.3	43.5
12-64-13	#3	6.5		14.7	12.3	10.1	5.2		1.5	9.4
12-64-14	*#3*	*8.5*		*15.7*	*12.3*	*12.1*	*5.3*		**3.6**	**4.9**
12-67-1	*D*	*8.5*		*15.7*	*12.2*	*11.3*	*9.3*		**<.01**	**1.8**
12-64-8	#3	10		16.7	12.2	12.4	9.7		0.1	7.1
12-64-17	*#3*	*12.5*		*18.0*	*12.3*	*12.7*	*11.2*		***0.1***	***3.9***
12-67-2	*D*	*12.5*		*18*	*12.2*	*12.7*	*12.1*		*0.3*	*6.2*
12-64-9	#3	15		20.0	12.3	12.6	12.2		0.1	21.3
12-64-21	#3	10		10.0	12.4	12.5	8.5		<.01	5.7
12-64-22	#3	10		16.7	12.4	12.4	7.0		.12	42.1
12-64-23	#3	10		25	12.4	12.4	6.1		.99	33.7
12-64-18	*#3*		*10*	*10.0*	*11.7*	*10.2*	*4.9*		**2.8**	**4.8**
12-67-3	*D*		*10*	*10.0*	*11.6*	*9.2*	*5.3*		**0.6**	**3.7**
12-64-19R	*#3*		*10*	*16.7*	*11.7*	*9.2*	*11.1*		**<0.1**	**2.3**
12-67-4	*D*		*10*	*16.7*	*11.6*	*8.9*	*5.1*		**1.3**	**1.8**
12-64-20	#3		10	25	11.6	8.7	5.0		2.4	7.5
12-64-10	#3		5	13.3	11.2	5.7	4.5		7.0	96.3
12-64-11R	#3		10	16.7	11.5	7.2	5.1		2.6	17.0
12-64-15	#3		11.5	18.0	11.6	9.45	4.9		13.2	1.2
12-64-16	*#3*		13	19.0	11.9	10.7	5.1		**1.8**	**0.8**
12-67-5	*D*		13	19	11.7	9.8	5.9		0.5	5.9
12-64-12	#3		15	20.0	11.5	10.4	5.3		9.8	.21

Additives are by weight %

TCLP soln #1 is pH 4.9 (TCLP acid pH test dictates soln #1)

TCLP soln #2 is pH 2.9 (TCLP acid pH test dictates soln #2)

Table 5. Extended Incubation Time (CaO and $Ca(OH)_2$) Using Samples From Phase II

Previous stabilized samples	MidRiver CaO %	$Ca(OH)_2$ %	H_2O %	Pb STLC mg/l 4/12/04	Pb STLC mg/l 6/9/04	pH filtrate 4/12/04	pH filtrate 6/9/04		Pb TCLP mg/l 4/12/04	Pb TCLP mg/l 6/9/04	pH filtrate 4/12/04	pH filtrate 6/9/04
12-51-3	7.5		20	7.0	2.5	11.8	11.1		36.8	.74	4.5	6.3
12-51-4	10		20	14.7	17.2	12.2	12.3		24.0	.48	4.9	11.8
12-51-7		7.5	20	22.1	101.9	8.3	9.3		22.4	8.0	4.5	5.7
12-51-8		10.0	20	22.2	5.2	9.5	9.8		19.8	.43	4.7	8.5

Table 6. TCLP and STLC Pb Analysis Extended Incubation Time

Test Number	Client ID	CaO %	Portland Cement %	$Ca(OH)_2$ %	H_2O %	pH: soil + amend	pH: STLC filtrate	pH: TCLP filtrate	TTLC Pb mg/kg	TCLP Pb mg/l	STLC Pb mg/l
Controls/ Untreated											
12-64-5	#3					7.3		5.1	950	.76	
12-64-6	#3						5.1				72.2
Treatments											
12-67-1	*D*	*8.5*			*15.7*	*12.2*	*11.3*	*9.3*		**<.01**	**1.8**
After 216 hours incubation						*12.2*	*12.1*	*9.2*		**0.3**	**1.4**
12-67-3	*D*		*10*		*10.0*	*11.6*	*9.2*	*5.3*		**0.6**	**3.7**
After 216 hours incubation						*11.6*	*9.1*	*5.2*		**1.3**	**1.6**
12-67-4	*D*		*10*		*16.7*	*11.6*	*8.9*	*5.1*		**1.3**	**1.8**
After 216 hours incubation						*11.6*	*8.0*	*5.0*		**1.9**	**6.7**

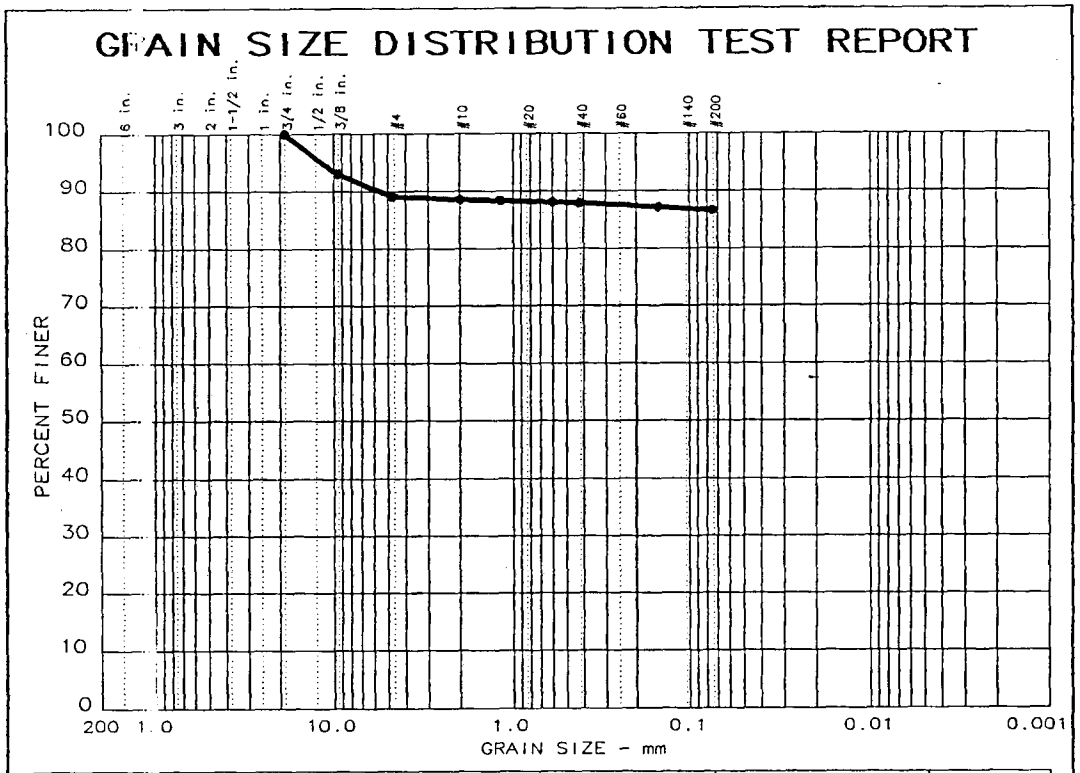
Table 7. Volume Increase Relative to Treatment

MT² Test #	Mare Island, CA Sample #3 (treatment H_2O %) Mass (g)	volume (cc)	cc/g	average cc/g	Mare Island, CA Sample #3 (air dried) average cc/g	cc/g	volume (cc)	mass (g)
Control, rep 1	22.8527	22.5	0.9846			0.9581	18.0	18.7869
Control, rep 2	29.5581	27.5	0.9304			ND	ND	ND
Control, rep 3	40.4655	41	1.0132	*0.9761*	*0.9572*	0.9561	32.5	33.9895
				% increase	% increase			
12-67-1	27.2783	30.0	1.0998	12.7	22.8	1.1753	29.0	27.6744
12-67-2	29.6551	31.0	1.0454	7.0	23.7	1.1843	29.0	24.4876
12-67-3	31.9190	33.0	1.0339	5.9	13.9	1.0902	28.0	25.6842
12-67-4	29.3738	31.5	1.0724	9.9	18.4	1.1334	27.0	23.8229
12-67-5	29.9796	30.0	1.0007	2.5	15.3	1.1035	26.0	23.5607

Treatments:

12-67-1	*8.5% CaO (Chemical Lime, 1/8"), 15.7% H_2O*
12-67-2	*12.5% CaO (Chemical Lime, 1/8"), 18% H_2O*
12-67-3	*10% Portland cement (Type II), 10% H_2O*
12-67-4	*10% Portland cement (Type II), 16.7% H_2O*
12-67-5	*10% Portland cement (Type II), 19% H_2O*

Table 8. Grain Size Distribution, Atterberg Limits and Moisture Content of Sample #3, MT[2] 130-5



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	10.9	2.5	86.6	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	71	36								

MATERIAL DESCRIPTION	USCS	AASHTO
● Elastic Silt	MH	A-7-5(37)

Project No. 66386.01
Project: MT
● Location: 130-5

Date: 6.11.94

Remarks:
Moisture Content 26.0%

GRAIN SIZE DISTRIBUTION TEST REPORT
GOODSON & ASSOCIATES, INC.
Consulting Engineers

Figure No. _____

TETRA TECH FW, INC.

July 20, 2004
FWSD-RAC-04-2399
5.0

Duane Rollefson
Remedial Project Manager
Southwest Division
Naval Facilities Engineering Command
BRAC Operations Office
1230 Columbia Street, Suite 1100
San Diego, California 92101-8517

SUBJECT: Mare Island Former Marine Corps Firing Range, TREATABILITY REPORT, PHASE III

Reference: Contract N68711-D-5713, Environmental Remedial Action Contract for Sites in Southern California, Arizona, New Mexico and Southern Nevada

Dear Mr. Rollefson,

Attached is the report of the soil stabilization testing, Phase III, as prepared by Metals Treatment Technologies, LLC (MT^2). The report presents the findings of a laboratory treatability study, which was a follow on stabilization study to the Phase I and Phase II as already completed by MT^2 for Tetra Tech FW, Inc.

The overall objective of the Phase III study was to evaluate the treatability of a bulk quantity of homogenized (by utilizing a trommel screen on site) contaminated soil from the small arms firing range. Leachable lead (Pb) concentrations were analyzed by the Toxicity Characteristics Leaching Procedure (TCLP) and the Cal Wet Na-citrate (STLC) test both before and after soil stabilization with quicklime (calcium oxide/CaO) and Portland Cement. Parameters, including incubation/cure time and stabilizing agent:water:soil ratios, were varied to develop formulations and a soil treatment concept that would provide acceptable results in accordance with regulatory criteria.

Prior to treatment, the bulk soil sample was determined non-hazardous by RCRA standards; however, the sample was above the California hazardous limit (STLC > 5.0 mg/l). When the alkalinity of the soil sample was increased by the addition of the stabilization agent, the leachable concentrations of Pb exceeded allowable TCLP levels. This indicates that the functionality of the stabilization chemical requires controlled dosage to avoid increasing TCLP leachable Pb while reducing the STLC leachable Pb. Addition of lower ratios of stabilization agents (≤ 5%) resulted in higher levels of leachable Pb than untreated soil.

1230 Columbia Street, Suite 500, San Deigo, CA 92101
Tel 619.234.8590 Fax 619.234.8591
www.ttfwi.com

The STLC test is a challenging test for stabilization technologies because the citrate compound used in the analysis procedure is a very powerful chelating (complex forming) agent. For the Phase III project, both CaO and Portland Cement were seen to be effective in reducing the STLC to below 5 mg/l, with the Portland Cement more effective, easier to reproduce, more consistent and stable over time.

Based on these results, we have concluded that 10% Portland Cement (type II) in combination with 10% water is the most efficient formulation to stabilize the soil sample to below the TCLP and STLC regulatory requirements, ultimately rendering the sample non-hazardous. However, including contingencies for field variability and given that Pb concentrations in the untreated soils from the MCFR will vary, we believe that stabilizing soils down to a California hazardous level would be the most feasible and cost effective treatment option. In their laboratory tests, MT^2 has proven that either Portland Cement (type II) (at 10%) or their own proprietary agent Ecobond Pb (at 1.5%) can be utilized to obtain this result.

It was beyond the scope of work for Phase III to confirm that field homogenization (trommeling) of the soils prior to stabilization would be effective and the only pre-process required to successfully execute stabilization of soils under field conditions. It is recommended that this be further explored through pilot testing in the field as the next step of the project.

Please review the enclosed report and if you have any questions, please do not hesitate to contact us at (619) 471-3532 (Kent) or (619) 471-3528 (Ulrika).

Sincerely,

Kent Weingardt
Project Manager

Ulrika T. Messer
Project Engineer

Attachment:
TREATABILITY REPORT, Phase III

Copy to:
David Godsey (06CM.DG) - SWDIV BRAC – San Diego
Jerry Dunaway (06CM.JD) – SWDIV BRAC – San Diego

TETRA TECH FW, INC.

TRANSMITTAL/DELIVERABLE RECEIPT

Contract No. N68711-98-D-5713 (RAC III)

Document Control No. 04-2399

File Code: 5.0

TO: Contracting Officer
Naval Facilities Engineering Command
Southwest Division
Ms. Beatrice Appling, 02R1.BA
1220 Pacific Highway
San Diego, CA 92132-5190

DATE: 07/21/04
CTO: 0073
LOCATION: Mare Island

FROM: Edwin Neil Hart
Neil Hart, Program Manager

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