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DRAFT

Full-Scale Bioremediation Windrow S-001, Batch Report

NSWC Crane
Crane, Indiana

Unit Identification Code: NO01 64
Contract No. N62467-93-D-1106

September 1998

Southern Division
Naval Facilities Engineering Command
North Charleston, South Carolina
29419-9010

DEPARTMENT OF THE NAVY
CRANE DIVISION
NAVAL SURFACE WARFARE CENTER
300 HIGHWAY 361
CRANE, INDIANA 47522-5000

IN REPLY REFER TO
5090
Ser 095/8195
05 OCT 1993

U.S. Environmental Protection Agency, Region V
Waste, Pesticides, & Toxics Division
Waste Management Branch
Illinois, Indiana, and Michigan Section
Attn: Ms. Carol Witt-Smith (DRP-8J)
77 West Jackson Blvd.
Chicago, IL 60604

Dear Ms. Witt-Smith:

Crane Division, Naval Surface Warfare Center (NAVSURFWARCENDIV Crane) submits for review and approval two copies of the Draft Pilot Scale 30% Soil Loading Batch Report for Full Scale Bioremediation Operations as enclosure (1) NAVSURFWARCENDIV Crane also submits for review and approval two copies of the Draft Windrow S-001 Batch Report for Full Scale Bioremediation Operations as enclosure (2). Enclosure (3) is the required certification statement.

NAVSURFWARCENDIV Crane point of contact is Ms. Christine D. Freeman, Code 09511, telephone 812-854-4423.

Sincerely,

[illegible] M. [illegible]
[illegible], Environmental Protection Department
[illegible] Direction of
the Commander

Encl:
(1) Draft PS 30% Soil Loading Batch Report for FS Operations
(2) Draft Windrow S-001 Batch Report for FS Operations
(3) Certification Statement

Copy to:
ADMINISTRATIVE RECORD
COMNAVSEASYSCOM (SEA OOT) (w/o encls)
IDEM (S. Riddle)
MK Crane (D. Beall) (w/o encls)
SOUTHNAVFACENGCOM (Code 1864) (w/o encls)

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

James M. Hamilton

SIGNATURE

DIRECTOR, ENVIRONMENTAL PROTECTION DEPARTMENT

TITLE

05 OCT 1999

DATE

Enclosure (3)

NSWC CRANE

DRAFT INITIAL **WINDROW** S-001 BATCH REPORT
FOR FULL-SCALE OPERATIONS

RESPONSES TO NSWC CRANE EPD COMMENTS

GENERAL COMMENTS

COMMENT 1: For consistency, make references to **windrow** as follows, "**Windrow** S-001".

RESPONSE 1: References to **windrow** have been changed to ""**Windrow** S-001".

COMMENT 2: For consistency, refer to the **end** date of the **windrow** as, "Day Last" instead of "Day Final".

RESPONSE 2: The end date of **Windrow** S-001 has been changed from "Day Final" to "Day Last".

COMMENT 3: For clarification, at the beginning state that Mix 7B information comes from Pilot Scale Operations.

RESPONSE 5: Tire last sentence of the second paragraph in the Executive Summary states that the Mix **7B** information has been obtained from pilot-scale operations.

SPECIFIC COMMENTS

COMMENT 1: Acronyms and Abbreviations.

a) Add the following to the list: FS-OP Full **Scale Operations** Plan for Soils Bioremediation Facility, FS-QAPP Full Scale Quality Assurance Project Plan, and **PS-TTR** Pilot Scale Treatability Test Report. Insert changes in the text after the first reference for each of the above mentioned reports.

b) The abbreviations for "not detected", "parts per million", and "**standard** unit" should be lowercase as well as in the **text.**

RESPONSE 1: a) Items noted above have been added to the Acronyms and Abbreviations section. These changes were also made in the text after the first reference for each of the above mentioned reports.

b) Abbreviations for "not detected", "parts per million", and "standard unit" have been changed to lower case in the text,

COMMENT 2: p. I-I 61.2 ¶1 Rewrite the last sentence as follows, "... (SWMUs): Ammunition Burning Ground (~~ABG —~~ SWMU 03/10); Rockeye Munitions Facility (~~Rockeye) —~~ SWMU-10115); Mine Fill A (MFA)– (SWMU-12/14); and Mine Fill B –(SWMU-13/14).

RESPONSE 2: The last sentence on page I-I, Section 1.2, first paragraph, has been rewritten as stated above.

COMMENT 3: p. I-I 61.2 ¶2 Add the word, "contamination" to the end of the last sentence.

RESPONSE 3: The word, "contamination" has been added to the end of the last sentence of the second paragraph in Section 1.2.

COMMENT 4: p. 1-1 §1.2 ¶3

a) Elaborate that Mix 7B consisting of 15% chicken manure, 25% soil, 60% straw was the recommend mix from Pilot Scale (because it is compared to later in several sections of the report).

b) Rewrite the third sentence as follows, ". in the ~~approved~~ Full-Scale Operations Plan for Soils Bioremediation Facility (FS OP) [MK, 1998b] approved by the U.S. Environmental Protection Agency, Region V (EPA)."

RESPONSE 4: a) The second sentence in the third paragraph in Section 1.2 has been rewritten to include the Mix 7B recipe.

b) The third sentence in paragraph 3 of Section 1.2 has been rewritten as stated above.

COMMENT 5: p. 1-2 §1.3 ¶1

a) Reference and show a map of the MFA grids where the soil was excavated.

b) In the last sentence a reference is made to Mix #1. Explain the amendment contents of Mix #1 in this paragraph.

c) Explain that Mix #1, even though it contained amendments, was considered soil in the windrow mix ratio because it was to be retreated.

RESPONSE 5: a) A sentence has been added to the end of the first paragraph of Section 1.3 referencing the excavation locations at MFA. Soil excavated from various MFA grid locations was stockpiled in Building 1 for use in windrow formation. Specific grid locations for soil used in the 30% windrow cannot be determined. MFA excavation locations are referenced in Figures E-l through El-4 of Appendix El of the FS-OP.

b) The amendment contents have been described.

c) The last sentence in the first paragraph in Section 1.3 explains the use of Mix #1.

COMMENT 6: p. 2-1 62.1 ¶1 Spell out, "Degrees Centigrade" in the second sentence.

RESPONSE 6: Degrees Celsius has been spelled out in the second sentence of the first paragraph of Section 2.1 and is consistent with the Acronyms and Abbreviations portion of the report.

COMMENT 7: p. 2-l 62.1 ¶2

a) Reference and include the daily process logs in Appendix B.

b) Rewrite the first sentence as follows, ". windrow turning according to the Field Standard Operating Procedure (SOP) 4 Section 3 of the Quality Assurance Project Plan for Full Scale Ooerations (QAPP) [MK, 1998c]."

c) Rewrite the second sentence as follows, ".. of the five cross sections, for a total of 30 monitoring locations."

d) Humidity is discussed in this paragraph. It should be discussed in Section 2.2 Moisture.

RESPONSE 7: a) A reference to average daily ambient temperature data has been added to the second paragraph of Section 2.1. A log of average daily ambient temperatures has been added to Appendix B.

b) The first sentence of the second paragraph in Section 2.1 has been rewritten as stated above.

c) The second sentence of the second paragraph in Section 2.1 has been rewritten as stated above.

d) References to humidity have been removed and are discussed in Section 2.2.

COMMENT 8: p. 2-2 §2.2

a) Rename this Section as, "Moisture".

b) Discuss humidity in this section. Reference humidity data in Appendix C.

c) In paragraph three of this section, identify from where the added moisture was received to rule out additional explosives contamination.

RESPONSE 8: a) Section 2.2 has been renamed "MOISTURE".

b) The second paragraph in Section 2.2 now discusses humidity and references Appendix C for humidity data.

c) The last sentence of the third paragraph of Section 2.2 describes the water source.

COMMENT 9: p. 2-3 92.3 ¶2 In the second sentence, replace the word, "pile" with "windrow". Check the entire document for this change.

RESPONSE 9: The word "pile" has been replaced with the word "windrow" in the second sentence in paragraph 2 of Section 2.3 and throughout the report.

COMMENT 10: p. 2-3 §2.3 ¶3

a) Rewrite the first sentence as follows, ".. twice daily, before ~~and after~~ turning and within 15 minutes after turning."

b) After the first sentence, reference the daily process logs

located in Appendix B.

c) Rewrite the second sentence as follows, "... as the temperature measurements according to SOP 4 Section 3 of the QAPP."

d) The statement made in the sixth sentence concerning better oxygenation in Full Scale (FS) then in Pilot Scale (PS) is not entirely correct. During PS, the oxygenation monitoring took place at a later time after turning than did the monitoring during FS. The oxygen level drops quickly, therefore monitoring at an earlier time after turning will yield a higher oxygen content.

RESPONSE 10: a) The first sentence in the third paragraph of Section 2.4 has been rewritten as stated above.

b) A reference to oxygen monitoring data has been inserted as the second sentence of the third paragraph in Section 2.3.

c) The second sentence in the third paragraph of Section 2.4 has been rewritten as stated above.

d) Acknowledged. The sixth sentence in the third paragraph of Section 2.3 has been removed.

COMMENT 11: p. 2-4 62.4

a) The title for this section should read, "pH" instead of "PH".

b) Rewrite the second sentence as follows, ".. specifications identified in Field SOP 4.0 Section 5 of the FS-QAPP ~~Quality Assurance Project Plan for Full Scale Operations (QAPP)~~ [MK, 1998c]."

c) Rewrite the last sentence as follows, "The data for pH monitoring ~~data are~~ is presented in Appendix E."

RESPONSE 11: a) The title for Section 2.4 has been changed to "pH".

b) The second sentence in Section 2.4 has been rewritten as stated above.

c) The last sentence of Section 2.4 has been rewritten as stated above.

COMMENT 12: p. 3-1 §3.0 ¶2

a) In the second sentence, the field test kits are referred to as SD I is this an abbreviation? If so, then spell it out and add to the acronyms/abbreviations if it is used more than once.

b) After the second sentence, add a reference for the field test kits SOPs.

RESPONSE 12: a) "SDI" has been spelled out in the text and added to the Acronyms and Abbreviations section of he report.

b) A reference for the field test kit SOPs has been added after the second sentence in the second paragraph of Section 3.0.

COMMENT 13: p. 3-l 63.0 ¶3 In the fourth sentence, add the name of the laboratory utilized for toxicity analysis and where the SOPs can be found for toxicity analysis.

RESPONSE 13: The name of the laboratory utilized for toxicity analysis has been added to the fourth sentence of the third paragraph in Section 3.0. The fourth paragraph now states where the laboratory SOPs can be found.

COMMENT 14: p. 4-l 64.0 This section needs to reference and include the raw data (metals, volatiles, & explosives) for the pre-excavation samples from contaminated soils used in the windrow.

RESPONSE 14: Soil excavated from various MFA grid locations was stockpiled in Building N for use in windrow formation. Specific grid locations for soil used in the formation of Windrow S-001 cannot be determined and the volume of analytical data for all of the pre-excavation samples collected to date is too extensive to include in this report. The report has been revised to indicate that this data is available at the Bioremediation Facility office.

COMMENT 15: p. 4-1 64.1 In this report, the methods listed to analyze for metals are 6010 and 7470; volatiles method is 8260. In the W N-30% Batch Report, the methods listed to analyze for metals is 6010; volatiles method is 8240. Shouldn't these methods be consistent because only the approved FS QAPP and FS OP were to be followed? Please correct appropriately.

RESPONSE 15: The methods listed in the Windrow 30% Batch Report and this Initial Batch Report have been revised and are consistent. Method 6010 and 7470 has been referenced for metals, and method 8240 has been referenced for volatiles. Because the excavation of soil took place prior to FS-QAPP approval, the methods utilized in Pilot-Scale Operations was utilized for analysis.

COMMENT 16: p. 4-1 84.2 ¶1

a) Typographical error: The statement in parentheses after the first sentence, does it belong with the first or second sentence.

b) Typographical error in the fifth sentence, "...was collected 26 dsays after pile "

c) Define the reporting limit and define the difference between reporting limit and a detection limit.

RESPONSE 16: a) The statement in parentheses after the first sentence belongs with the first sentence. An period has been added after the statement in parentheses.

b) The word "says" has been changed to "days" in the fourth sentence of the first paragraph in Section 4.1.

c) Reporting limit has been defined in the ninth sentence of the first paragraph in Section 4.2. The difference between the reporting limit and detection limit has not been defined since detection limit is not mentioned in the report. Additionally, only reporting limit is provided in the cleanup objectives tables in the FS-OP.

COMMENT 17: p. 4-1 §4.2 ¶2

a) In this report, the criteria for explosive compound contamination reduction between Day 0 and Day Last is listed as 95%. In the W N-30% Batch Report, the criteria is listed as 90-99% reduction. Shouldn't these methods be consistent because only the approved FS QAPP and FS OP were to be followed? Please correct appropriately.

b) Rewrite the first sentence as follows, "... between the Day 0 and Day ~~Final~~ Last explosive compound concentrations was obtained."

RESPONSE 17: a) The FS-QAPP states the criteria of 90-99% reduction of toxicity and mobility to achieve remediation goals. The contamination reduction range of 90-99% has been added to the first sentence of the second paragraph in Section 4.2.

b) The first sentence of the second paragraph in Section 4.2 has been rewritten as stated above.

COMMENT 18: p. 5-2 65.2 ¶3 In the first sentence, reference the FS-QAPP and where in the FS-QAPP the criteria for the items listed can be found.

RESPONSE 18: The location of the criteria listed in the first sentence as well as a reference to the FS-QAPP has been included in the first sentence of the third paragraph in Section 5.2.

COMMENT 19: p 5-2 65.2 ¶4 In the last sentence, replace “data quality objectives” with “DQO”.

RESPONSE 19: “data quality objectives” has been replaced by “DQO” in the last sentence of the fourth paragraph in Section 5.2.

COMMENT 20: p. 5-4 §5.5 Rewrite the third sentence as follows "Field ~~Standard Operating Procedures (~~SOPs~~)~~ were established to ..."

RESPONSE 20: The third sentence in Section 5.5 has been rewritten as stated above.

COMMENT 21: Appendix B Remove humidity data and move to Appendix C.

RESPONSE 21: Humidity data has been removed from Appendix B and placed in Appendix C.

COMMENT 22: Appendix C Add “Average Daily Percent Humidity Chart” to the table of contents.

RESPONSE 22: “Average Daily Percent Humidity Chart” has been added to the table of contents in Appendix C.

FULL-SCALE BIOREMEDIATION WINDROW S-001, BATCH REPORT

NSWC CRANE
CRANE, INDIANA

September 25, 1998

CONTRACT N62467-93-D-1106
DELIVERY ORDER #0009
STATEMENT OF WORK #0007

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EXECUTIVE SUMMARY

On-site bioremediation of explosive-contaminated soil utilizing a windrow composting process began at Naval Surface Warfare Center Crane as the preferred interim measures treatment alternative. Activities associated with the construction and monitoring of the first windrow have been summarized in this document to demonstrate acceptable performance of full-scale operations per recommendations made during pilot-scale activities.

The first windrow of full-scale operations, Windrow S-001, was created on April 15, 1998 using amendment recipe identified as Mix 7B in the pilot-scale operations. The amendments of chicken manure and straw were mixed with explosive contaminated soil from Mine Fill A, at a soil loading of 25%, to form a windrow. By turning the windrow each day, proper aeration, temperature, oxygen, pH and moisture were maintained to provide optimal conditions for contaminant degradation. The information for Mix 7B has been obtained from pilot-scale operations.

Process monitoring of temperature, water holding capacity, oxygen, and pH were performed according to the frequency specified in the *Full-Scale Operational Plan* for Soils *Bioremediation facility* [MK, 1998b]. In addition, field screening of explosives was performed to monitor the progress of Windrow S-001. The results of the field screening were used to identify when confirmation samples could be collected for analysis at an off-site laboratory. Laboratory analysis of compost samples on the last day of composting (i.e., Day 26) was performed at Southwest Laboratories of Oklahoma, Inc. The values of these results demonstrate that performance and remedial goals established for this process were met. All data were evaluated to verify that data quality objectives described in the Quality *Assurance Project Plan for Full-*Scale *Operations* [MK, 1998c] have been met.

The results of this initial batch confirm the predictions and recommendations of pilot-scale activities. All performance goals and remedial goals established for this process have been achieved. It is recommended that full-scale operations continue using the technology developed in pilot-scale activities and the windrow size developed for full-scale operations. Subsequent pilot-scale testing of windrows with increased percentages (i.e., 30% vs. 25%) of contaminated soil should be pursued. Such testing will involve pilot-scale size windrows. This testing will examine the possibility of increasing the volume of soil treated while maintaining a 28 day windrow cycle.

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ACRONYMS AND ABBREVIATIONS

°C	Degrees Centigrade
2A46DT	2-Amino-4,6-dinitrotoluene
4A26DT	4-Amino-2,6-dinitrotoluene
CAAA	Crane Army Ammunition Activity
DQO	Data Quality Objectives
EPA	U.S. Environmental Protection Agency
FS-OP	Full-Scale Operational Plan for Soils Bioremediation Facility
FS-QAPP	Full-Scale Quality Assurance Project Plan
HMX	cyclotetremethylenetetranitramine
IM	Interim Measures
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
MFA	Mine Fill A
MK	Morrison Knudsen Corporation
MRLs	Method Reporting Limits
MS	Matrix Spike
MSD	Matrix Spike Duplicate
nd	not detected
NSWC	Naval Surface Warfare Center
ppm	parts per million
PS-TTR	Pilot-Scale Treatability Test Report
QAPP	Quality Assurance Project Plan
QC	Quality Control
RDX	cyclotrimethylenetrinitramine
RPD	relative percent difference
RSD	relative standard deviation
SOP	Standard Operating Procedure

SOUTHNAVFACENGCOM	Southern Division, Naval Facilities Engineering Command
SU	standard units
SWMU	Solid Waste Management Unit
TNT	2,4,6-trinitrotoluene
WHC	Water Holding Capacity

1.0
INTRODUCTION

1.1 OBJECTIVES

This report summarizes the operational activities for the first windrow constructed during full-scale operations at Naval Surface Warfare Center (NSWC) Crane. The purpose of this report is to demonstrate that the Windrow S-001 construction and composting techniques derived as a result of the *Pilot-Scale Treatability* Test Report (PS-TTR) [MK, 1998a] are capable of meeting project objectives during full-scale operations.

1.2 BACKGROUND

NSWC Crane, located in southwestern Indiana, provides support for equipment, shipboard weapons systems, and ordnance. This site also supports Crane Army Ammunition Activity (CAAA) which includes production and renovation, storage, shipment, demilitarization and disposal of conventional ammunition. Explosive-contaminated soils resulting from the above operations have been identified at four Solid Waste Management Units (SWMUs): Ammunition Burning Ground (SWMU-03/10); Rockeye Munitions Facility (SWMU-10115); Mine Fill A (SWMU-12/14); and Mine Fill B (SWMU-13/14).

On site bioremediation of the contaminated soil utilizing a windrow composting process has been selected as the preferred treatment alternative for the Interim Measures (IM) at these four SWMUs. In this process, microbial degradation of explosive compounds is performed by mixing contaminated soil with organic material. By optimizing the availability of organic material, temperature, moisture content, pH, and oxygen availability, the microbial activity can be stimulated. The result is the production of residual organic and inorganic material with significantly reduced explosives compounds contamination.

A pilot-scale test was completed at NSWC Crane to determine the compost mix which provided the optimum environment for microorganism growth and degradation of explosive compounds in contaminated soil. The recommended mix from pilot-scale operations was the Mix 7B, which consisted of 15% chicken manure, 25% soil, and 60% straw. The results of pilot testing are presented in the PS-TTR [MK, 1998a]. Recommendations from this report were incorporated in the Full-Scale *Operational Plan* for Soils *Bioremediation Facility* (FS-OP) [MK, 1998b] approved by the U.S. Environmental Protection Agency, Region V (EPA). The work is being undertaken by Morrison Knudsen Corporation (MK) for Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM), under Contract Number N62467-93-D-1106,

1.3 WINDROW DEVELOPMENT

The first compost windrow under full-scale operations, Windrow S-001, was created on April 15, 1998 in the south building consisting of 211 cubic yards of screened contaminated soil excavated from Mine Fill A (MFA) and the remaining pilot-scale Mix #1 compost which did not degrade the explosive compounds during the pilot-scale treatability demonstration. The 151 cubic yards of soil from MFA comprised of mixed clay, silt, and silty clay and contaminants, primarily included 2,4,6-trinitrotoluene (TNT), cyclotrimethylenetrinitramine (RDX), and cyclotetremethylenetetranitramine (HMX). Of the 211 cubic yards, 60 cubic yards was obtained from the partially treated material from pilot-scale Mix #1, a mix tested and not selected for full-scale operations. Mix # 1 consisted of 15 cubic yards of contaminated soil from MFA and 45 cubic yards of various amendments (POTW sludge, alfalfa, sawdust, and woodchips) which did not sufficiently degrade the explosive compounds, and therefore required re-treatment. Mix #1 was considered soil in the Windrow S-001 mix ratio because it was to be re-treated.

The amendments to Windrow S-001 were loaded on a volume basis into a grinder/mixer unit to homogenize each mix. The amendments included 124 cubic yards of chicken manure and 495 cubic yards of straw. This resulted in a compost windrow consisting of 15% chicken manure, 60% straw, and 25% contaminated soil by volume as specified in the FS-OP [MK, 1998b]. A record of the compost recipe and suppliers of amendments is provided in Appendix A.

2.0
PROCESS MONITORING

After the contaminated soil was loaded into the windrows, the windrow turning machine (SCARAB@) mixed and reformed the windrows. The windrows were turned once a day to maintain proper aeration, temperature, oxygen, pH and moisture. In addition, water was added as needed to maintain optimal moisture content. These process parameters were monitored to evaluate and provide optimal conditions for contaminant degradation. The values of these process parameters were compared to the performance goals established in the FS-OP [MK, 1998b]. A summary of the process parameters and significance of each parameter is described below.

2.1 TEMPERATURE

Temperature is a primary indicator of successful thermophilic cornposting. The process goal is to maintain an average windrow temperature near 55 Degrees Centigrade (“C) for approximately two weeks. The average windrow temperature should rise from 25 to 40°C within the first few days of formation, and continue rising to within the temperature range of 40 to 60°C, and maintain that temperature range for at least two weeks. This temperature profile indicates a healthy, metabolically active windrow. Temperature decrease over time below 50°C is viewed as an indicator that the windrow is nearing the end of its thermophylic cycle.

Windrow temperature was monitored twice daily, before and after each windrow turning according to the Field Standard Operating Procedure (SOP) 4 Section 3 of the *Quality Assurance Project Plan for* Full-Scale *Operations (*FS-QAPP) [MK, 1998c]. Temperature readings were taken using a hand-held temperature probe at six sampling/monitoring locations at each of the five cross sections, for *a* total of 30 monitoring locations. These locations were selected to provide representative temperature profiles for the inner core and outer near-surface conditions. Ambient air temperature inside the buildings was monitored daily using an alcohol thermometer to determine any correlation between ambient temperature and windrow temperature of Windrow S-001 A clear correlation did not exist between these variables. Summaries of the average daily Windrow S-001 temperature, average daily ambient temperature, and graphs are presented in Appendix B. The average ambient temperatures ranged between 4 and 18°C, as shown in the graph provided in Appendix B.

Pre-turn temperatures have been determined to be more useful for evaluation and comparison because they represent heat development over time. Average temperature is defined as the average of the 30 monitoring locations in each windrow. Windrow S-001 exhibited a rapid temperature increase to 40°C within two days. Temperatures continued to rise above 55°C and were maintained for approximately two weeks. In some cases, average temperature exceeded 65°C but was readily reduced with

aeration and/or moisture addition to within the optimum operating range. This temperature pattern mimics conditions shown in the PS-TTR [MK, 1998a] generated from Mix 7B. Based on the results of temperature monitoring, Windrow S-001 was able to maintain optimum temperatures for enhancing biodegradation.

2.2 MOISTURE

Water holding capacity (WHC) is monitored to ensure optimum operating conditions for microbial growth and contamination degradation. WHC is the ratio of the percent moisture of the compost to the percent moisture of the compost at the point of saturation. The calculation for this value is show in Section 4.5 of Field SOP 4.0 of the FS-QAPP [MK, 1998c].

The humidity inside the building was monitored daily using a hygrometer to determine any correlation between percent humidity and WHC of the windrow. The average daily relative humidity ranged from 61 to 100% for Windrow S-001. No correlation was found to exist between percent humidity and water holding capacity. Daily humidity data is presented in Appendix C.

The operating goal for composting moisture content is 40 to 60% maximum WHC. If WHC levelsare excessively low or high, proper composting and explosives degradation may be affected. Too little moisture content inhibits microbial movement and nutrient availability in the compost windrow. Excessive moisture fills the void spaces needed for proper aeration, thus reducing oxygen levels and retarding aerobic microbial growth. Water was generally added to the point of saturation when WHC levels fell below 45%. Potable water from an on-site source was generally added when WHC levels fell below 45%.

WHC monitoring was performed three times a week according to the operations schedule prior to windrow turning, unless moisture was added on that day, in which case WHC was monitored after the addition of water and subsequent turning. Moisture level samples were collected from each of the five cross sections. At each cross section, sample locations 1, 2, and 3 were composited for a total of five composited samples per windrow. Average WHC data are provided in Appendix C.

Due to high levels of evaporation during the composting cycle, water was added at three times during the composting activities to maintain moisture content at approximately 50% maximum WHC. Table 2-l summarizes the moisture additions for Windrow S-001.

Overall, Windrow S-001 exhibited excellent moisture holding capacity which enhanced biodegradation. Additional water was added to Windrow S-001 in comparison to pilot-scale due to the increased size of the windrow, however WHC values remained consistent with levels found in the PS-TTR [MK. 1998a] for Mix 7B. At no time during

TABLE 2-1 SUMMARY OF MOISTURE ADDITIONS TO WINDROW # S-001		
DATE OF ADDITION	WINDROW AGE (DAYS)	VOLUME ADDED (GALLONS)
4/19/98	4	2000
5/1/98	16	1500
5/8/98	23	1500

the process was leachate observed from Windrow S-001. The average daily WHC ranged between 42% and 51% during the twenty-six day cycle of Windrow S-001,

2.3 OXYGEN

Oxygen levels of up to ambient atmospheric or about 20% are preferred in a compost windrow, and 5% is considered the minimum for rapid compost degradation. Oxygen levels below 1% indicate anaerobic conditions. If sufficient oxygen levels are not maintained, proper microbial degradation may not occur, thermophilic temperatures may not be maintained, and putrefaction of organic matter may occur. However, anaerobic conditions commonly exist in a compost windrow throughout most of each day, and depending on the density of the compost, aerobic conditions may occur for only for one to two hours following turning.

The oxygen available to microbes in a windrow is the result of aeration by turning. Therefore, oxygen availability is a function of the air-filled pore volume within the windrow, which is in turn a function of porosity and moisture content. As the compost windrow is turned and degrades, the porosity is reduced which in turn reduces available oxygen. Similarly, increasing the moisture content also reduces available oxygen,

Oxygen levels were monitored twice daily, before turning and within 15 minutes after turning. The oxygen monitoring data for Windrow S-001 are provided in Appendix B. Oxygen level measurements were collected using a hand-held probe at the same locations as the temperature measurements according to SOP 4 Section 3 of the FS-QAPP [MK, 1998c]. The oxygen monitoring data are provided in Appendix D. Windrow S-001 exhibited excellent oxygenation levels. Levels of oxygen greater than 12% occurred on most days after turning. Operations were able to maintain Windrow S-001 within the optimum oxygen conditions during initial activities. The graph demonstrates the progressive reduction in oxygen levels both pre and post-turn. After Day 14 the pre-turn oxygen levels are less than 6.6% which are suggestive of the decreased porosity as the compost degrades.

2.4 pH

The pH of the compost windrow is measured to ensure that the pH neutral environment is obtained during operations. Five composite samples were collected on a weekly basis to monitor pH prior to windrow turning according to the sampling specifications identified in Field SOP 4.0 of the FS-QAPP [MK, 1998c]. The pH of the compost windrows in pilot-scale operations normally remained within the range of 5.5 to 9 standard units (su). Values obtained for Windrow S-001 were between 8.44 and 8.66 su which are consistent with the pilot scale operations. The pH of the Windrow S-001 during full-scale operations was not adjusted during composting activities. The data for pH monitoring is presented in Appendix E.

3.0
FIELD SCREENING FOR EXPLOSIVE COMPOUNDS

RDX, TNT, and HMX are the major explosive compounds present at Mine Fill A based upon previous sampling results. Field test kits provide a cost effective method of determining approximate concentrations and minimize the number of samples submitted for off-site analysis. There is currently no field test kit available for the analysis'of HMX, however field test kits were used for RDX and TNT analysis. RDX and TNT are representative of the explosive compounds present and give a good indication of the degradation of the other explosive compounds.

Process monitoring of the RDX and TNT concentrations within Windrow S-001 for analysis was performed on operational days 7, 14, and 21 to monitor the reduction process. One composite sample was collected per cross-section and analyzed for RDX and TNT using the Strategic Diagnostic, Incorporated (SDI) Ensys® Field Test Kits. SOPs for the field test kits is presented in the FS-QAPP [MK, 1998c]. When field screening indicated non-detectable RDX and TNT levels, confirmation samples were collected and submitted to an off-site laboratory for analysis of all target constituents, The purpose of the field test kits is to dictate when samples will sent for off-site analysis. Table 3-l provides a summary of the field test kit data results. The associated worksheets (raw data) are contained in Appendix F.

The field data demonstrates a progressively decreasing concentration of RDX and TNT during composting operations. On day 21 all TNT and RDX levels were below detectable levels using the field test kits. Confirmation samples were collected and submitted to Southwest Laboratories of Oklahoma for analysis by EPA Method 8330 on day 26. Day Last sampling was delayed five days due to scheduling conflicts with Aqua Survey, Incorporated, the laboratory utilized for toxicity analysis. SOPs for toxicity analysis are presented in *Appendix G, Toxicity Testing and Leaching Procedures,* of the FS-QAPP [MK, 1998c]. Toxicity analysis of this Windrow S-001 was performed on Day Last, and the results of this study will be provided under a separate report.

TABLE 3-I
SUMMARY OF FIELD TEST KIT RESULTS

Cross Section	DAY 7		DAY 14		DAY 21	
	RDX (ppm)	TNT (ppm)	RDX (ppm)	TNT (ppm)	RDX (ppm)	TNT (ppm)
3	28.8	nd	8.7	nd	nd	nd
5	33.2	nd	8.0	nd	nd	nd
7	59.8	nd	10.5	nd	nd	nd
9	36.9	nd	11.3	nd	nd	nd
11	21.2	2.5	6.2	nd	nd	nd

Notes: ppm: parts per million
nd: not detected

4.0
LABORATORY ANALYSIS

The constituents of concern for MFA include explosives, metals and volatile organics. Analysis of the SWMU specific contaminants listed in Section 1.4.2.1 of the FS-QAPP [MK, 1998c] was performed for all pre-excavated soil by Southwest Laboratory of Oklahoma, Inc.

4.1 METALS AND VOLATILES ANALYSIS

Samples of contaminated soil from MFA were collected analyzed for metals (EPA Methods 6010 and 7470) and volatiles (EPA Method 8240) prior to excavation. Levels of site-specific total metals and volatiles contamination did not exceed any of the established Industrial Use Cleanup Goals (Table l-2 of the FS-QAPP [MK, 1998c]) and therefore, further metal and volatile analysis were not required during cornposting activities. Analytical data associated with pre-excavation characterization samples are available at the Bioremediation Facility Office.

4.2 EXPLOSIVES ANALYSIS

Samples collected for explosives analysis by EPA Method 8330 prior to excavation showed levels which exceeded Industrial Use Cleanup Goals (Table l-2 of the FS-QAPP [MK, 1998c]). Soil exceeding the Industrial Use Cleanup Goals was screened, composted and submitted for analysis on the day of Windrow S-001 formation (Day 0). Field screening was performed weekly to monitor the RDX and TNT levels. A final compost sample was collected 26 days after Windrow S-001 formation (Day Last) once the field test kits indicated RDX and TNT levels were below detectable levels. Samples for explosive analysis were collected from each of the five cross sections. At each cross section, locations 1, 2, and 3 grab samples were collected for a total of fifteen samples per windrow as outlined in the FS-OP [MK, 1998b]. The fifteen samples were averaged to obtain a single Day 0 average concentration for each explosive compound, and a single Day Last average concentration for each explosive compound. The average concentration was calculated by using the result when concentrations were above the reporting limits. Reporting limit is defined as the threshold value below which the laboratory cannot accurately quantify, although it is possible to detect analytes below this threshold value. For those results which fell below the reporting limit, the value of the reporting limit was used in the calculation. Calculation of the average concentration in this manner presents a worst case scenario in calculation of the average concentration and percent reduction of the target constituents. A summary of the these results is located in Appendix G.

Degradation of the explosives compounds was evaluated for each compound in order to ensure that the Industrial clean-up levels were achieved and that the criteria of 90-99% reduction range between the Day 0 and Day Last explosive compound

concentrations was obtained. HMX, RDX, TNT, 2A46DT, and 4A26DT were the only compounds found in the initial Day 0 characterization. Most of the Day 0 samples contained very high levels of RDX, HMX and TNT which required sample dilutions in order to bring them into the calibration range of the instrument. Due to the high levels of RDX, HMX and TNT and the subsequent dilutions, the reporting limits of other target analytes were elevated to reflect this dilution. By evaluating the average concentration of each explosive contaminant from Day 0 to Day Last, the percent reduction was calculated. Appendix H contains the reduction values for each contaminant. Percent reduction is only applicable to those compounds found to be present above the reporting limits during the Day 0 characterization.

5.0
DATA QUALITY CONTROL

All data associated with Windrow S-001 monitoring were verified, and at least 10% of the samples were validated by MK personnel following the procedures outlined in Section 9.0 of the FS-QAPP [MK, 1998c]. Data was compared with field and laboratory quality control (QC) sample data to assess the data's usability for supporting operational decisions. The results of this data verification and validation are presented in this section.

Data associated with the monitoring of Windrow S-001 were verified by reviewing chain-of-custody forms, sample preservation records, analytical holding times, requested turnaround times, and sample data in comparison to analytical quality assurance objectives. Data quality objectives (DQOs) were established to ensure the quality of the analytical data produced by the laboratory. These quality objectives were evaluated by monitoring the precision, accuracy, representativeness, completeness, and comparability of the measured data which are outlined in Table 3-I through Table 3-8 of the FS-QAPP [MK, 1998c]

5.1 PRECISION

Precision is a measure of the reproducibility of measurements under a given set of conditions. Precision is usually stated in terms of relative standard deviation (RSD) or relative percent difference (RPD). Field duplicates and replicate samples were used to determine the precision of the sampling process. Laboratory matrix spikes (MS) and matrix spike duplicates (MSD) as well as laboratory control samples (LCS) and lab control sample duplicates (LCSD) were used to determine the precision of the analytical process.

Field duplicates were collected at a frequency of 10% of the total number of samples collected. Two field duplicates were collected, one each on Day 0 and Day 26. A summary of the relative percent difference is shown in Appendix I. RDX, TNT, and HMX showed RPD levels less than 25% in both field duplicates collected during Windrow S-001 monitoring. One explosive contaminant, 4-Amino-2,6-dinitrotoluene (4A26DT), had an elevated RPD value of 72% in the Day 0 field duplicate. This high RPD can be attributed to the non-homogeneous matrix type of Day 0 composting material.

Precision in the laboratory is assessed through the calculation of RPD and limits are established by EPA SW 846 methods. Laboratory duplicates consisting of MS/MSD were performed on each analytical batch of samples processed. Several matrix spike recoveries exceeded acceptable RPD values in the Day 0 analysis. In these cases, non-homogeneity of the sample matrix contributed to the increased variability seen in

the recovery of the matrix spike analytes. All analytes in Day 26 analysis had acceptable RPD values less than 40%. In all cases, acceptable RPD values were obtained in the analysis of the LCSILCSD.

Precision of the field test kits was also evaluated using sample duplicates. Sample duplicates were analyzed with the Field Test Kits for explosive analysis to assess the precision of these test kits. Analysis of sample duplicates for the test kits was performed at a frequency of 5%. Sample duplicate analysis showed RPD values less than 45% for all replicate field analysis performed.

5.2 ACCURACY

Accuracy is a measure of the bias in a measurement system, and is defined as the closeness of the reported value to the true value. The accuracy of a measurement system was assessed by evaluating the results of quality control samples such as matrix spikes, analytical surrogates and the use of field blanks and equipment rinsate blanks. Accuracy is expressed as a percent recovery of a compound from a sample spiked with known concentrations of target compounds. Accuracy for laboratory samples is also assessed through adherence to all sample handling, preservation and holding times. All samples were handled properly, preserved correctly, and adhered to the holding times established for this project.

Field blanks and equipment rinsate blank data are used to identify potential sources of error introduced during sampling or any source of contamination in the rinse water. Equipment rinse blanks were collected for each batch of samples submitted to the laboratory. A field blank was also collected from each source of dionized water every month representing the water source used for equipment decontamination. Explosive contamination was not found in any rinse blank or field blank. Based on these results it is clear that no explosive cross-contamination has occurred during collection, shipping, or storage.

Laboratory accuracy was assessed against the criteria established in Table 3-2 of the FS-QAPP [MK, 1998c] through the analysis of surrogates, laboratory control standards, sample matrix spikes, or standard reference materials and the determination of percent recoveries. Surrogate spikes are known amounts of non-target compounds which are introduced into all samples prior to extraction in order to evaluate the efficiency of the sample preparation and analysis. Surrogate recoveries were acceptable for all samples analyzed.

The LCS and LCSD are samples prepared in the laboratory and consist of clean soil or water spiked with known amounts of target analytes which is processed through the same preparation as field samples. Evaluation of the spike recoveries gives an indication of analysis accuracy in a clean matrix. Recoveries of all standard matrix spikes (lab control samples) were acceptable based on project DQO.

Sample MS and MSD are field samples which have been spiked with a known amount of target analytes and processed through the preparation and analysis with the field samples. Two spiked aliquots (MS/MSD) were processed and the results compared to known concentrations of the spiking solution to determine recoveries. The recoveries of the matrix spike samples were varied. In some of situations, elevated recoveries are likely due to low spiking concentrations used in the laboratory relative to the concentration of the analyte found initially in the sample. This was seen primarily of HMX, TNT, and RDX due to the high sample concentrations of these compounds. In the remaining situation two explosive contaminants, 4-ADNT, and 2-ADNT had elevated recoveries in the matrix spike of 150% and 145% respectively. This elevated recovery is attributed to the dilution required for analysis based on levels of other explosive contaminants in the sample.

Laboratory method blanks can also be used to evaluate bias in the measurement. Method blanks were prepared and analyzed with the samples in order to evaluate potential target compounds or interferences from laboratory glassware, reagents and/or solvents used in the preparation and analysis of samples. Laboratory method blanks did not show the presence of any target analytes above the reporting limits. Results of the method blanks were acceptable for all analytes.

Accuracy of the field test kits were evaluated through the analysis of a field check standard. This standard was analyzed with each batch of samples processed at a frequency of 10%. The results of all field checks standards are recorded on the field test sheets in Appendix F. Recoveries of these standards are within acceptable limits established for this project.

5.3 REPRESENTATIVENESS

The representativeness of the data is the degree to which data represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Representativeness is a qualitative parameter which is controlled through sampling in accordance the sampling program outlined in the FS-QAPP [MK, 1998c]. All documentation from sampling and analysis demonstrates that the requirements of the QAPP have been adhered to and proper sampling techniques and sample preservation procedures have been followed.

5.4 COMPLETENESS

Completeness is a measure of the amount of valid data obtained from an analytical data set compared to the amount that was expected to be obtained under normal sampling and analytical conditions. Completeness is based on only those samples collected and submitted for laboratory analysis. All results were obtained and determined valid for samples collected from Windrow S-001 for monitoring purposes. This indicates a 100% completeness for Windrow S-001.

5.5 COMPARABILITY

Comparability expresses the confidence with which one data set can be compared to another. Samples from Windrow S-001 were considered comparable because they were collected following the same sample collection procedures throughout windrow monitoring. Field SOPs were established to collect representative samples in a consistant manner. In addition, all samples were analyzed by the same analytical methods throughout this project as established by the laboratory SOPs. Minor changes in analysis did not occur throughout the analysis of Windrow S-001 which is demonstrated by the low variability seen in the data. The analytical laboratory's QC program was designed to establish consistency in the performance of the analytical process.

6.0
CONCLUSIONS

During full-scale operations, remedial goals will be the industrial level remediation goals for all SWMU specific contaminants. These goals are presented in Table 1-2 of the FS-QAPP [MK, 1998c]. The compost mix, identified as Mix 7B tested to be successful in pilot-scale activities was utilized to create Windrow S-001 in full scale operations. This mix, consisting of 15% chicken manure, 60% straw, and 25% contaminated soil, was successful at meeting remediation goals for all SWMU specific contaminants at levels below the industrial clean-up levels by Day 26. The results of Windrow S-001, the first windrow of full-scale operations favorably compare to pilot-scale operational predictions. Further, residential clean-up goals presented in Table l-l of the FS-QAPP [MK, 1998c] were obtained for all explosive contaminants by Day 26.

Windrow S-001 has also reached its performance goals by demonstrating at least 90% reduction of all contaminants as required by the Full-Scale Operations Plan. The average degradation was 98%. The lowest degredation was seen with 2A46DT with 97% reduction, and the highest degredation occurred with TNT and RDX, both with 99% reduction. The observations presented here indicate that bioremediation by composting utilizing the amendment recipe selected has met the performance and remedial goals of this project. Based on the success of the first windrow, full-scale operations will continue with this composting amendment mixture for contaminated soil in MFA. Increase in soil loading may be performed based on results of the pilot-scale size windrow testing using 30% soil.

7.0
REFERENCES

MK, 1998a. *Pilot Scale Treatability Test Report, Soils Bioremediation Facility - NSWC Crane, Crane, Indiana.* Delivery Order Number 0009, Contract Number N62467-93-D-l 106. Prepared by Morrison Knudsen Corporation, Environmental Services Group. Revision #1, September 02, 1998.

MK, 1998b. *Full-Scale Operational Plan for Soils Bioremediation Facility, NSWC Crane, Crane, Indiana.* Delivery Order Number 0009, Contract Number N62467-93-D-1106. Prepared by Morrison Knudsen Corporation, Environmental Services Group. Revision 2, March 12, 1998.

MK, *1998c. Quality Assurance Project Plan for Full-Scale Operations, Soils Bioremediation Facility, NSWC Crane, Crane, Indiana.* Delivery Order Number 0009, Contract Number N62467-93-D-1106. Prepared by Morrison Knudsen Corporation, Environmental Services Group. Revision 2, March 12, 1998.

APPENDIX A
WINDROW RECORD OF RECIPE

TABLE OF CONTENTS

DESCRIPTION	PAGES
Record of Recipe	4 pages

(SOUTH) **RECORD** OF RECIPE (MIX NO. **7B**)

Building # 3 **Windrow** # 1 **PERFORMED By:** RDayhoff

DATE: 4/1/2198 PAGE 1 OF 4 **INSPECTED BY:** Tom Boyd

Design Quantity: (PER BATCH) **Chicken Manure** 3 **CY** 4350 **Pounds**
Straw 12 **CY** 2200 **Pounds**
Soil 5 **CY** 11000 **Pounds**

Batch Number	CHICKEN MANURE Supplier: WABASH VALLEY FARM		STRAW Supplier: DAYHOFF FARM		SOIL Location: MINE FILL 'A' & MIX #1-PS		TOTAL ACTUAL QUANTITY	
	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds
1	3.5	7700	12.25	3600	5	11,000	20.75	22300
2	3.	6250	12.	3000	5	11000	20	20250
3	3.25	7900	12	3100	5	11,000	20.25	22000
4	3.00	6100	12.	3200	5	11,000	20	20300
5	3.00	6300	11.75	2800	5	11,000	19.75	20100
6	3.10	7000	12.	3300	5	11,000	20.1	21300
7	3.00	6400	12.50	3600	5	11,000	20.5	21000
8	3.00	6600	12.00	3000	6	13,200	21.0	22800
9	3.00	6690	12.00	3460	5	11,000	20	21150
10	3.25	7440	12.00	3280	5	11,000	20.25	21720
11	3.00	7000	11.75	3100	5	11,000	19.75	21100
12	3.00	6700	12.00	3500	5	11,000	20	21200
13	3.00	6800	12.25	3700	5	11,000	20.25	21500
14	3.	6400	12.00	3400	5	11,000	20	20800
15	3.25	6900	12.00	3300	5	11,000	20.25	21200
16	3.25	7200	12.00	3200	6	13200	21.25	23600
17	3.00	6400	12.00	3100	5	11,000	20	20500
18	3.5	7800	12.75	3800	5	11,000	21.25	22600
—	—	—	—	—	—	—	—	—
Total THIS PG.	56.1	123640	217.25	59440	92	202400	365.35	385480

Bale 2RD 1.5m; 2RD 1.5D; 2.25; 2; 2.5; 2.25; 2.25; 2.25; 2.00; 2.25; 2.2; 2.25; 2.; 2.; 2; 2.5

Comments: SOIL WAS LOADED ON BATCH 1 TO 28 ON 4/14/98 AND ON BATCH 29 TO 41 ON 4/15/98. SOIL BLENDED W/ AMENDMENTS ON 4/15/98

RECORD OF RECIPE (MIX NO. 78)

Building # ~~Windrow~~ South # 1 PERFORMED BY: DP Dayhoff

DATE: 4/13/98 PAGE 2 of 4 INSPECTED BY: Tom Dayhoff

Design Quantity: Chicken Manure 3 CY 4350 Pounds
(PER BATCH) Straw 12 CY 2200 Pounds
Soil 5 CY 11000 Pounds

Batch Number	CHICKEN MANURE Supplier: WABASH VALLEY FARM		STRAW Supplier: DAYHOFF FARM		SOIL Location: MINE FILL A & MIX #1-PS		TOTAL ACTUAL QUANTITY	
	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds
Bales								
2.5	19	3.5	7700	12.5	3600	5	11,200	21	22300
2.0	20	2.75	6000	11.25	5000	5	11,000	19.5	20000
2.25	21	3.00	6900	12.00	3150	6	13200	21	23250
							35200 ~~48100~~	
Total THIS PG	9.25	20600	36.25	9750	16	~~25100~~	61.5	65550

Comments:

RECORD OF RECIPE (MIX NO. 7B)

Building # (3) South Windrow # 1 PERFORMED BY: DP Dayhoff

DATE: 4/14/98 PAGE 3 of 4 INSPECTED BY: [illegible]

Design Quantity: Chicken Manure 3 CY 4350 Pounds
(PER BATCH)
Straw 1/2 CY Y Pounds
Soil 5 CY 11,000 Pounds

Batch Number	CHICKEN MANURE Supplier WABASH VALLEY FARM		STRAW Supplier: DAYHOFF FARM		SOIL Location: MINE FILL A & MIX #1-PS		TOTAL ACTUAL QUANTITY	
Bales	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds
2 22	3.00	6800	12.25	3200	5	11,000	20.25	21000
2.25 23	3.00	6400	12.25	3500	5	11,000	20.25	20900
2.25 24	2.75	6000	12.25	3600	5	11,000	20	20600
2.00 25	2.70	5850	11.75	2900	5	11000	19.45	19750
2.00 26	3.00	6300	11.75	3000	5	11000	19.75	20300
2.5 27	2.75	5900	12.00	3400	5	11000	19.75	20300
2.25 28	3.00	6200	12.00	3400	5	11000	20	20600
2.25 29	2.70	5600	12.00	3600	6	13200	20.7	22400
2.00 30	2.90	5900	12.00	3200	5	11000	19.9	20100
2.5 31	3.00	6000	12.50	4050	5	11000	20.5	21050
2.0 32	3.00	6680	12.00	3380	5	11000	20	21060
2.5 33	3.00	6250	12.50	4400 WET	5	11000	20.5	21650
2.0 34	2.75	5500	12.00	3500	6	13200	20.75	22200
2.25 35	2.75	5400	12.00	3600	5	11000	19.75	20000
2.5 36	3.25	6640	12.00	3800	5	11000	20.25	21440
2.5 37	2.75	5400	12.00	3700	5	11000	19.75	20100
2.25 38	3.25	6700	12.00	3100	5	11000	20.25	20800
2.25 39	3.25	6500	12.00	3200	5	11000	20.25	20700
—	—	—	—	—	—	—	—	—
Total THIS PG	52.8	110020	217.25	62530	92	202400	362.05	374950

Comments:

RECORD OF RECIPE (MIX NO. 7B)

Building # (3) South Windrow # 1 PERFORMED By: P Dayhoff

DATE: 4/21/98 of 4 INSPECTED BY: [illegible]

Design Quantity: Chicken Manure 3 CY 4350 Pounds
(PER BATCH) Straw 2200 2 CY _____ Pounds
Soil ~~1~~ 5 CY 1000 Pounds
TDD

Batch Number	CHICKEN MANURE Supplier WABASH VALLEY FARM		STRAW Supplier DAYHOFF FARM		SOIL Location: MINE FILL A & MIX #1-P5		TOTAL ACTUAL QUANTITY	
	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds
2.5 40	2.85	5600	12.25	3900	6	13200	21.1	22700
2.25 41	3.00	5800	12.00	3600	5	11000	20	20400
TOTAL THIS PG	5.85	11400	24.25	7500	11	24200	41.1	43100
Total ALL PGS	124	2656600	495	139~~775~~ 2250 TDD	211	~~455400~~ 464200 TDD	830	869080

Comments:

APPENDIX B
TEMPERATURE SUMMARY RECORDS

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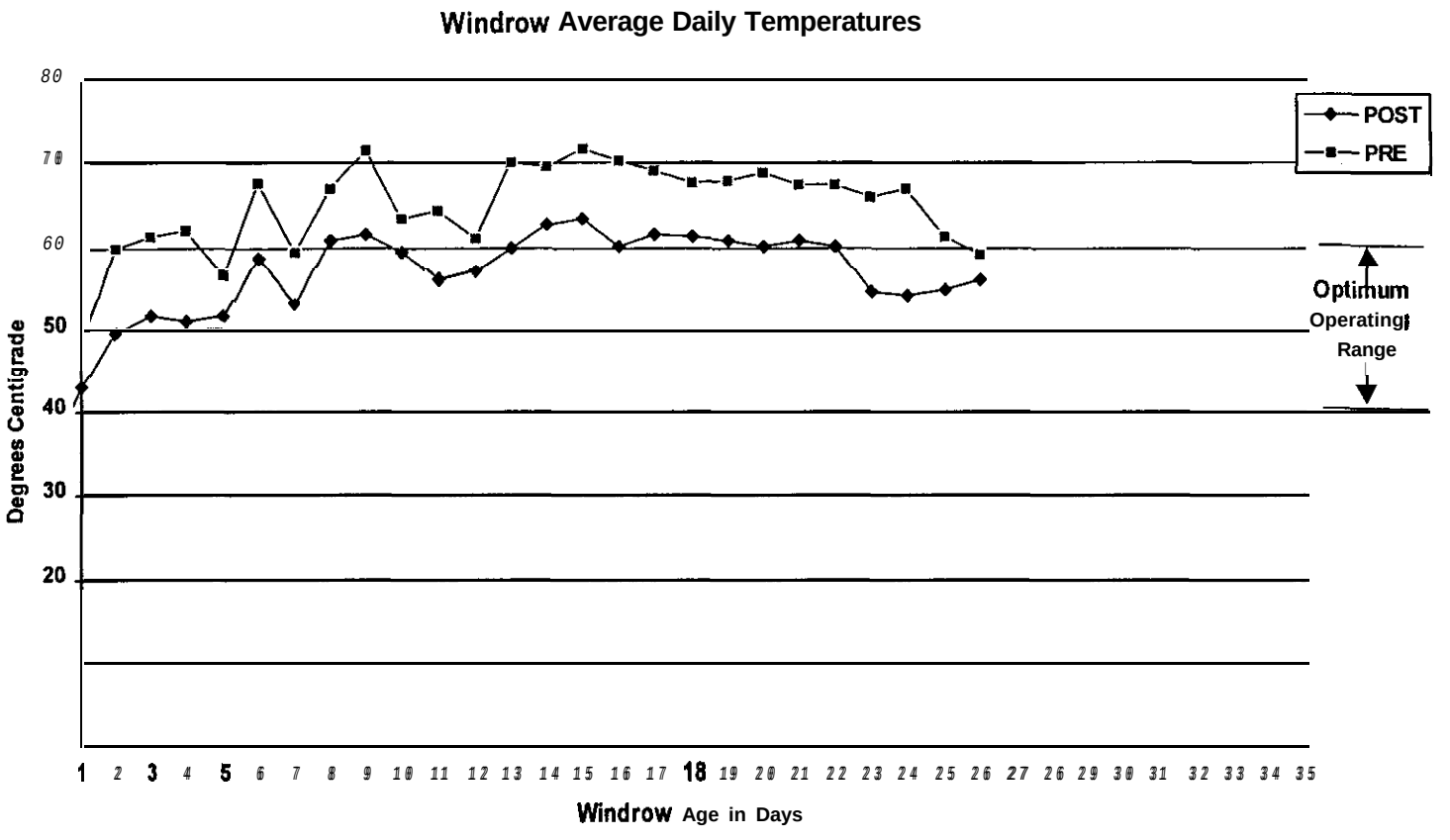
DESCRIPTION	PAGES
Windrow Average Daily Temperature Chart	1 page
Windrow Average Daily Temperature Data	1 page
Average Ambient Daily Temperature Chart	1 page
Average Ambient Daily Temperature Data	1 page

NSWC Crane BioFacility Full Scale Windrow SO01

Constructed April 15, 1998



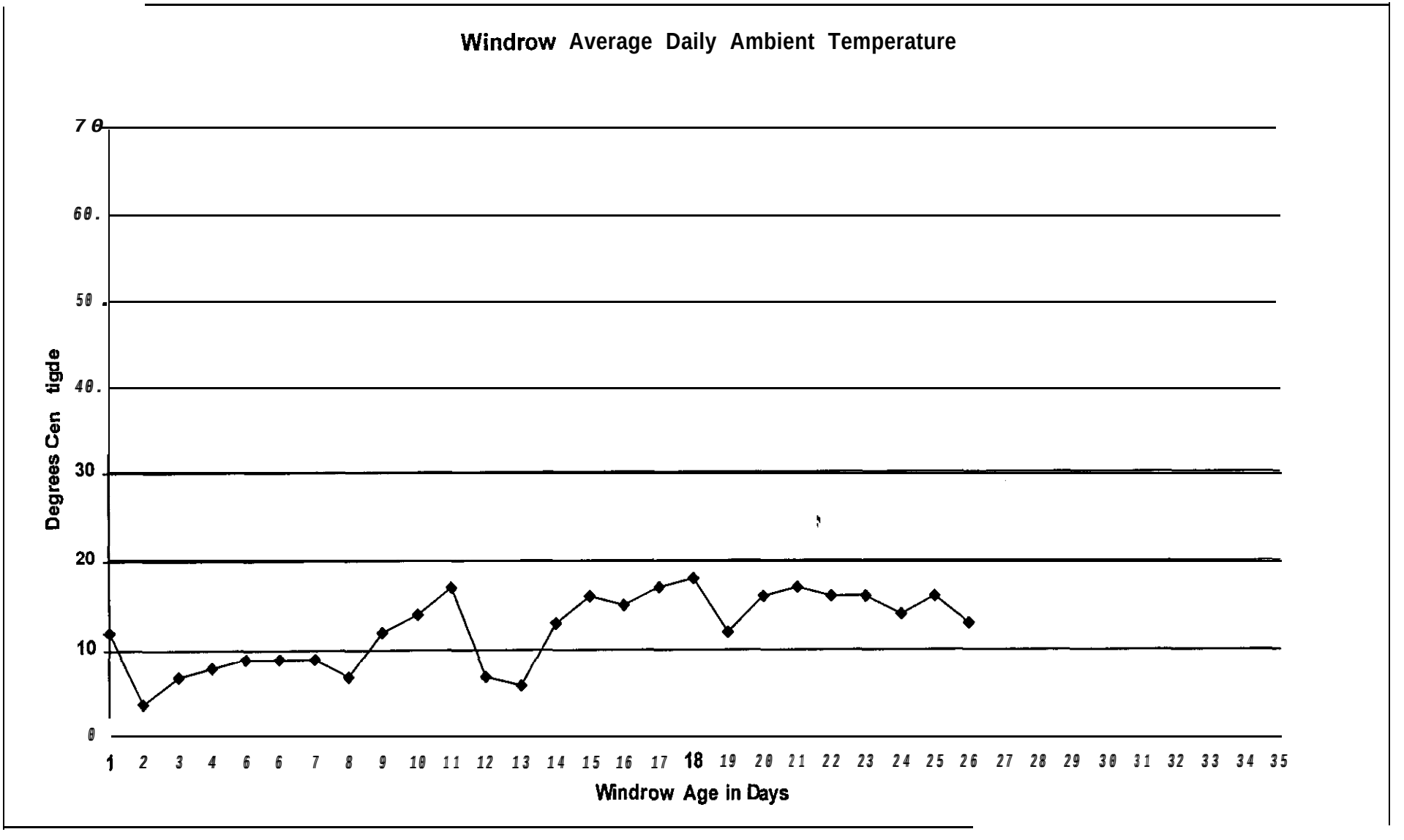
Morrison Knudsen Corporation

Average Daily Windrow Temperature Summary Report

Windrow Number	Construction Date	Date Monitored	Age (Days)	PRE-Turn (Deg C)	POST-Turn (Deg C)
.001	4/15/98	4/15/98	0		33.53
		4/16/98	1	48.57	43.07
		4/17/98	2	59.90	49.70
		4/18/98	3	61.20	51.67
		4/19/98	4	62.30	50.87
		4/20/98	5	56.83	51.53
		4/21/98	6	67.70	58.60
		4/22/98	7	59.40	53.30
		4/23/98	8	67.03	60.73
		4/24/98	9	71.37	61.50
		4/25/98	10	63.50	59.47
		4/26/98	11	8437	56.10
		4/27/98	12	61.13	56.93
		4/28/98	13	70.00	59.83
		4/29/98	14	69.60	62.83
		4/30/98	15	71.77	63.50
		5/1/98	16	70.33	60.20
		5/2/98	17	69.20	61.43
		5/3/98	18	67.70	61.40
		5/4/98	19	67.83	60.80
		5/5/98	20	68.90	60.07
		5/6/98	21	67.43	60.87
		5/7/98	22	67.50	60.07
		5/8/98	23	66.07	54.33
		5/9/98	24	67.10	53.87
		5/10/98	25	61.30	54.77
		5/11/98	26	59.17	55.80

All average temperatures ore in degrees centigrade

NSWC Crane BioFacility Full Scale Windrow Monitoring Activity



Morrison Knudsen Corporation

Daily Ambient Temperature Summary Report

Windrow Number	Construction Date	Date Monitored	Age (Days)	Temperature (Deg C)
01	4/15/98	4/15/98	0	12.00
		4/16/98	1	12.00
		4/17/98	2	4.00
		4/18/98	3	7.00
		4/19/98	4	a.00
		4/20/98	5	9.00
		4/21/98	6	9.00
		4/22/98	7	9.00
		4/23/98	a	7.00
		4/24/98	9	12.00
		4/25/98	10	14.00
		4/26/98	11	17.00
		4/27/98	12	7.00
		4/28/98	13	6.00
		4/29/98	14	13.00
		4/30/98	15	16.00
		5/1/98	16	15.00
		5/2/98	17	17.00
		5/3/98	18	18.00
		5/4/98	19	12.00
		5/5/98	20	16.00
		5/6/98	21	17.00
		5/7/98	22	16.00
		5/8/98	23	16.00
		5/9/98	24	14.00
		5/10/98	25	16.00
		5/11/98	26	13.00

All temperatures are in degrees centigrade
Tuesday, September 29, 1998

APPENDIX C
MOISTURE SUMMARY RECORDS

TABLE OF CONTENTS

DESCRIPTION	PAGES
Windrow Daily WHC Summary Data	1 page
Windrow WHC and Moisture Addition Chart	1 page
Average Daily Percent Humidity Chart	1 page

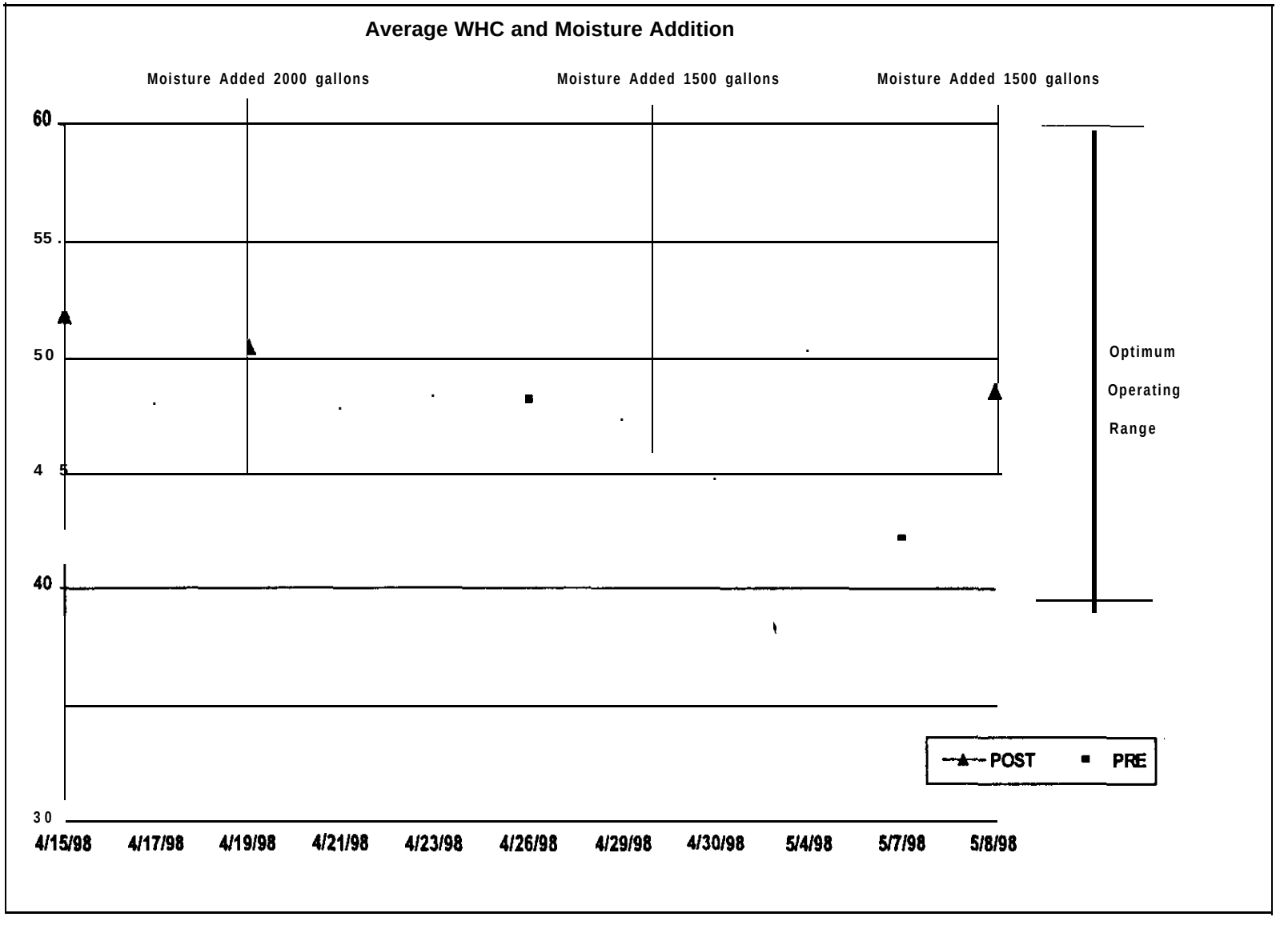
Average Daily Windrow WHC Summa y Report

'indrow Number	Construction Date	Date Monitored	Age (Days)	PRE-Turn (%)	POST-Turn (%)
s001	4/15/98	4/15/98	0		51.86
		4/17/98	2	48.08	
		4/19/98	4		50.48
		4/21/98	6	47.88	
		4/23/98	8	48.40	
		4/26/98	11	48.22	
		4/29/98	14	47.40	
		4/30/98	15	44.86	
		5/4/98	19	50.30	
		5/7/98	22	42.14	
		5/8/98	23		48.60

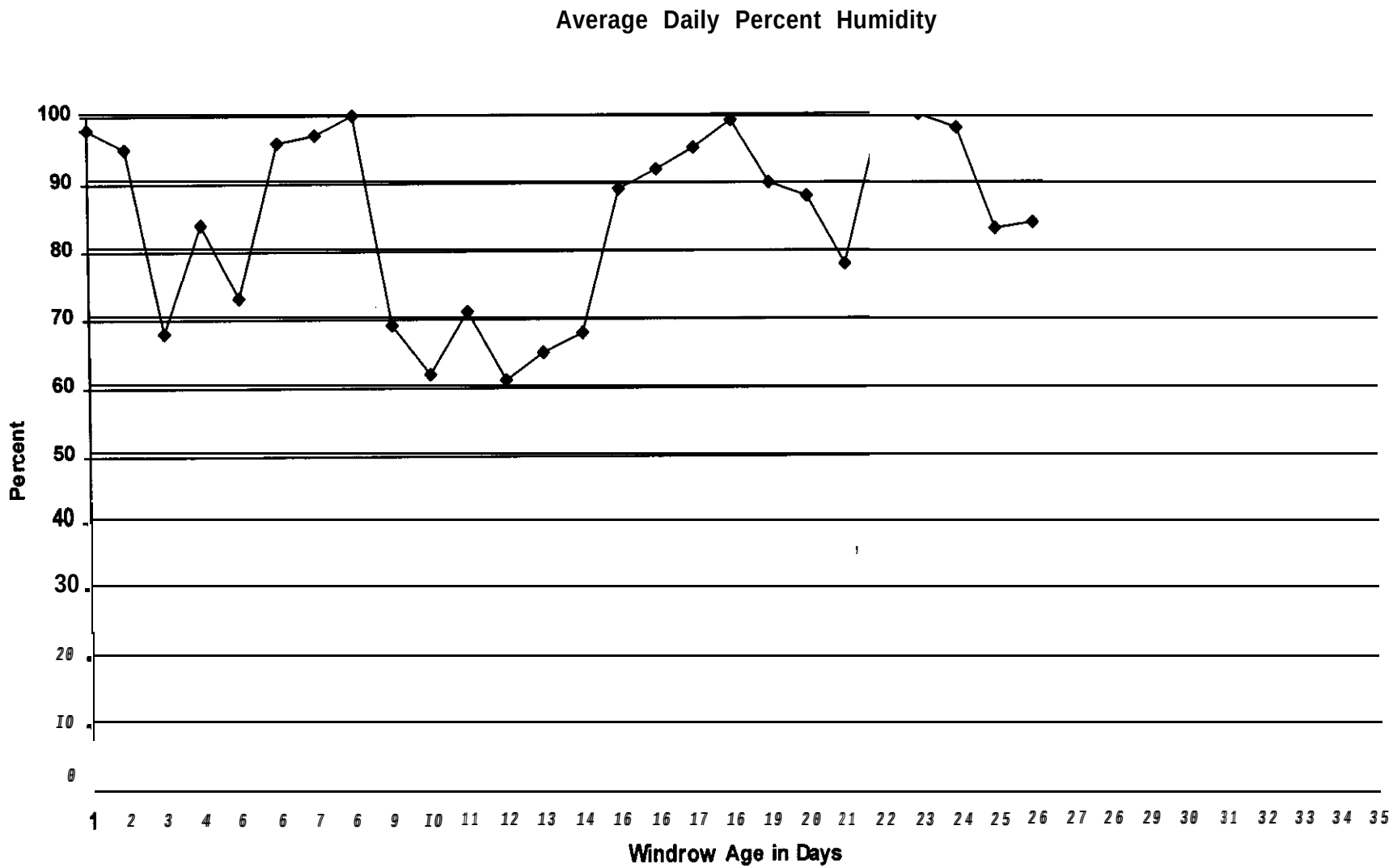
All overage MWHC values are expressed in percent

Generated: 29-Sep-98

NSWC Crane BioFacility Full Scale Windrow Monitoring Activity



NSWC Crane Full Scale Windrow Monitoring Activity



Morrison Knudsen Corporation

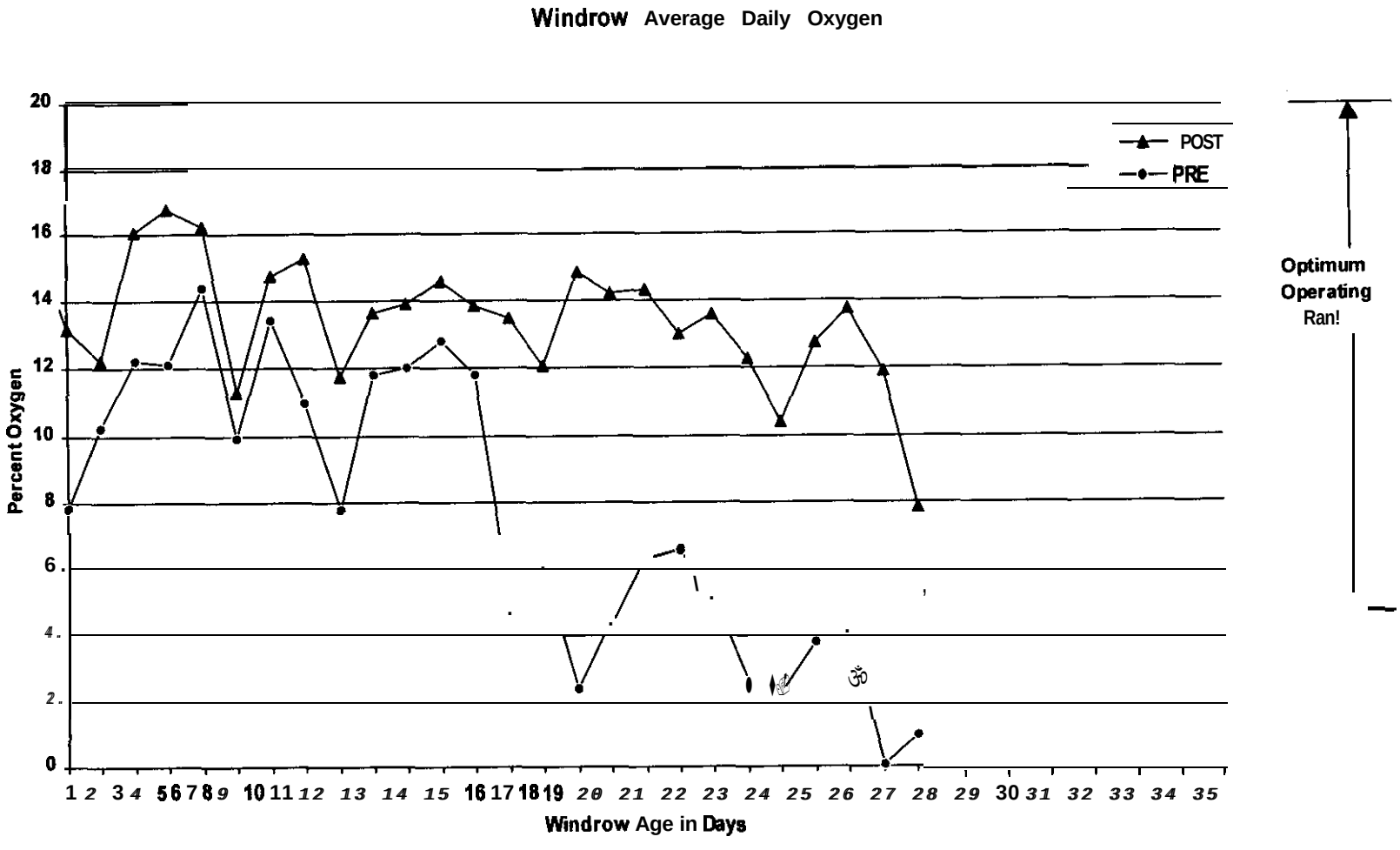
APPENDIX D
OXYGEN SUMMARY RECORDS

TABLE OF CONTENTS

DESCRIPTION	PAGES
Windrow Daily Oxygen Summary Chart	1 page
Windrow Daily Oxygen Summary Data	1 page

NSWC Crane BioFacility , ull Scale Windrow S-001

Constructed April 15, 1998



Morrison Knudsen Corporation

Average Daily Windrow Oxygen Summary Report

Windrow Number	Construction Date	Date Monitored	Age (Days)	PRE-Turn (%)	POST-Turn (%)
S001	4/15/98	4/15/98	0		16.00
		4/16/98	1	7.63	13.17
		4/17/98	2	10.23	12.23
		4/18/98	3	12.23	16.07
		4/19/98	4	12.13	16.73
		4/20/98	5	14.37	16.20
		4/21/98	6	9.93	11.27
		4/22/98	7	13.43	14.77
		4/23/98	8	10.97	15.27
		4/24/98	9	7.77	11.77
		4/25/98	10	11.83	13.67
		4/26/98	11	12.03	13.93
		4/27/98	12	12.83	14.60
		4/28/98	13	11.80	13.87
		4/29/98	14	4.70	13.50
		4/30/98	15	6.07	12.07
		5/1/98	16	2.40	14.67
		5/2/98	17	4.37	14.23
		5/3/98	18	6.37	14.33
		5/4/98	19	6.57	13.00
		5/5/98	20	5.17	13.60
		5/6/98	21	2.60	12.27
		5/7/98	22	2.30	10.40
		5/8/98	23	3.77	12.77
		5/9/98	24	4.13	13.73
		5/10/98	25	0.07	11.90
		5/11/98	26	0.97	7.83

All average Oxygen values are expressed as a percent

Generated: 29-Sep-98

APPENDIX E
PH SUMMARY RECORDS

TABLE OF CONTENTS

DESCRIPTION	PAGES
Windrow Daily pH Summary Data	1 page

Average Daily Windrow PH Summary Report

Windrow Number	Construction Date	Date Monitored	Age (Days)	PRE-Turn (STD Units)
S001	4/15/98	4/15/98	0	
		4/23/98	6	6.44
		4/29/98	14	6.56
		5/8/98	23	6.66

All average PH values are expressed in standard units

Generated: 08-Jul-98

APPENDIX F
FIELD TEST KIT DATA

TABLE OF CONTENTS

DESCRIPTION	PAGES
TNT/RDX Field Test Kit Data .	6 pages

RDX SOIL TEST KIT WORKSHEET

SAMPLE # Cross Section	ABSORBANCE	RDX CONC., PPM $\frac{RDX_{abs} - 0.014}{0.0225} \times 1.1$
~~3 100%~~	~~0.433~~	~~18.6 × 1.1 = 20.5~~
~~5 100%~~	~~0.588~~	~~25.5 × 1.1 = 28.1~~
7 100%	0.83	36.3 × 1.1 = 39.9
9 100%	0.875	38.3 × 1.1 = 42.1
11 100%	0.447	19.2 × 1.1 = 21.2
3 100%	0.602	26.1 × 1.1 = 28.8
7 1/2	0.626	27.2 × 1.1 = ~~30~~ 29.9 × 2 = 59.8
5 100%	0.715	31.2 × 1.1 = 34.3
9 1/2	0.308	13.1 × 1.1 = 14.4 × 2 = 28.8 do over
5 1/2	0.354	15.1 × 1.1 = 16.6 = 33.2
9 1/5	0.165	6.7 × 1.1 = 7.4 × 5 = 36.9
9 1/2	0.299	12.7 × 1.1 = 13.9 × 2 = 27.9
4/22/97		

Post-it® Fax Note 7671
Date 7/6/98 # of pages ▶ 10
To Valarie
From Peter
Co./Dept.
Co.
Phone #
Phone #
Fax #
Fax #

7/22/98 1) Abs "background" 0.000 2) Abs "control" 0.19 3) Abs "Nitrate/Nitrite" _____
7/.. 98 0.000 0.138

1/2711 0

TNT SOIL TEST KIT WORKSHEET

Abs background 0.000 am 2pm

Abs control 0.341 a.m. 0.335 pm

1	2	3	4	5	6
SAMPLE #	Abs initial	Abs sample	Abs initial x#2	Abs final (Column 3 - Column 4)	TNT CONC ppm (Column 5/0.0323)
Method	0.007	0.005	—	—	—
3 100%	0.020	0.026	0.04	—	—
5 100%	0.020	0.023	0.04	—	—
7 100%	0.017	0.024	0.034	—	—
9 100%	0.016	0.027	0.032	—	—
11 100%	0.016	0.048	0.032	0.016	0.5×5=2.5
3 100%	0.002	0.009	0.004	0.005	0.16×5=0.8
5 100%	0.003	0.084	0.006	0.078	2.4×5=12
7 100%	0.002	0.007	0.004	0.003	<1
9 100%	0.003	0.011	0.006	0.005	<1
1 100%	0.002	0.008	0.006	0.002	<1

P. MK Dat 7

Maddox
5/1/98

RDX **SOIL** TEST KIT WORKSHEET

SAMPLE #	ABSORBANCE	RDX CONC., PPM $\frac{RDX_{abs} - 0.014}{0.0225} \times 1.1$
B10-S-001-14-3	0.191	7.9 x 1.1 = 8.7
B10-S-001-14-5	0.178	7.3 x 1.1 = 8.0
B10-S-001-14-7	0.228	9.5 x 1.1 = 10.5
B10-S-001-14-9	0.246	10.3 x 1.1 = 11.3
B10-S-001-14-11	0.139	5.6 x 1.1 = 6.2
method	0.01	—

1) Abs "background" 0.000 2) Abs "control" 0.244 3) Abs "Nitrate/Nitrite" _____

11/30/98

TNT SOIL TEST KIT WORKSHEET

Abs background 0.002 am / 0.000 pm Abs control 0.33

	1	2	3	4	5	6
	SAMPLE #	Abs initial	Abs sample	Abs initial x 2	Abs final (Column 3 - Column 4)	TNT CONC ppm (Column 5/0.0323) x 5
phil. pm	S001 DAY 14 3	0.021	0.032	0.042	–	–
	S001 DAY 14 5	0.021	0.033	0.042	–	–
A.M	S001 DAY 14 7	0.022	0.038	0.044	–	–
	S001 DAY 14 9	0.023	0.035	0.046	–	–
	S001 DAY 14 11	0.023	0.030	0.046	–	–
chemlier	Method	0.003	0.004	0.006	–	–
	S001 Day 14 7 dup	0.011	0.023	0.022	0.001	nd
	S001 Day 0 R2 3-1	0.018	0.412	0.036	0.376	11.6 x 5 = 58.2
	S001 Day 0 R2 5-2					
	S001 Day 0 R2 7-3					
	S001 Day 0 R2 9-1					
	S001 Day 0 R2 11-2					
	S001 Day 14 9 dup	0.003	0.014	0.006	.008	0.25 x 5 = 1.25

Chev.

RDX **SOIL** TEST **KIT WORKSHEET**

SAMPLE #	ABSORBANCE	RDX CONC., PPM $\frac{RDX_{abs} - 0.014}{0.0225}$
Soil-21-3	0.014	
Soil-21-5	0.012	
Soil-21-7	0.016	
Soil-21-9	0.013	
Soil-21-11	0.010	

1) Abs "background" 0.001 2) Abs "control" 0.187 3) Abs "Nitrate/Nitrite" _____

Chevalier

TNT SOIL TEST KIT WORKSHEET

$Abs_{background}$ 0.010 $Abs_{control}$ 0.335

1	2	3	4	5	6
SAMPLE #	$Abs_{initial}$	Abs_{sample}	$Abs_{initial}$ x#a	Abs_{final} (Column 3 - Column 4)	TNT CONC ppm (Column 5/0.0323) x 5
M004-13-3	0.005	0.021	0.01	0.011	0.3x5=1.7 nd
M004-13-5	0.005	0.021	0.		nd
M004-13-7	0.005	0.019			nd
M004-13-9	0.004	0.038	0.008	0.03 ~~0.93~~	0.93x5=4.6 nd
M004-13-11	0.009	0.023			nd
method	0.001	0.003			nd
M002-20-3	0.006	0.021			nd
M002-20-5	0.012	0.021			nd
M002-20-7	0.014	0.032			nd
M002-20-9	0.013	0.03			nd
M002-20-11	0.01	0.023			nd
S001-21-3	0.006	0.023			nd
S001-21-5	0.005	0.038			nd
S001-21-7	0.004	0.016			nd
S001-21-9	0.005	0.022			nd
S001-21-11	0.004	0.015			nd
dup	0.007	0.023			nd

APPENDIX G
LABORATORY ANALYTICAL DATA

TABLE OF CONTENTS

DESCRIPTION **PAGES**

Average Windrow Explosive Summary Report Day 0. . . . . 1 page
Average Windrow Explosive Summary Report Day 26 . . . . . 1 page

Average Windrow Explosive Summary Report

Windrow	Compound	Construction Date	Date Monitored	Age (Days)	Avg. Cone. (UG/KG)
s001	135TNB	4/15/98	4/15/98	0	12500
	13DNB	4/15/98	4/15/98	0	12500
	246TNT	4/15/98	4/15/98	0	122547
	24DNT	4/15/98	4/15/98	0	12500
	26DNT	4/15/98	4/15/98	0	13000
	2A46DT	4/15/98	4115198	0	8648
	2NT	4/15/98	4/15/98	0	12500
	3NT	4/15/98	4/15/98	0	12500
	4A26DT	4/15/98	4/15/98	0	15273
	4NT	4/15/98	4/15/98	0	12500
	HMX	4/15/98	4/15/98	0	155725
	NB	4/15/98	4/15/98	0	13000
	PETN	4/15/98	4/15/98	0	12500
	RDX	4/15/98	4/15/98	0	1215500
	TETRYL	4/15/98	4/15/98	0	32500

Average Windrow Explosive Summary Report

Windrow	Compound	Construction Date	Date Monitored	Age (Days)	Avg. Conc. (UG/KG)
S001	135TNB	4/15/98	5/11/98	26	250
	13DNB	4/15/98	5/11/98	26	250
	246TNT	4/15/98	5/11/98	26	377
	24DNT	4/15/98	5/11/98	26	250
	26DNT	4/15/98	5/11/98	26	260
	2A46DT	4/15/98	5/11/98	26	250
	2NT	4/15/98	5/11/98	26	250
	3NT	4/15/98	5/11/98	26	250
	4A26DT	4/15/98	5/11/98	26	250
	4NT	4/15/98	5/11/98	26	250
	HMX	4/15/98	5/11/98	26	2098
	NB	4/15/98	5/11/98	26	260
	PETN	4/15/98	5/11/98	26	250
	RDX	4/15/98	5/11/98	26	993
	TETRYL	4/15/98	5/11/98	26	650

APPENDIX H
EXPLOSIVE REDUCTION SUMMARY

TABLE OF CONTENTS

DESCRIPTION	PAGES
Average Windrow Explosive Reduction Summary	2 pages

Average Windrow Explosive Summary Report

Windrow	Compound	Construction	Date	Date Monitored	Age (Days)	Avg. Conc. (UG/KG)
S001	135TNB		4/15/98	4/15/98	0	12500
soot	135TNB		4/15/98	5/11/98	26	250
				135TNB	Percent	Reduction 98
S001	13DNB		4/15/98	4/15/98	0	12500
S001	13DNB		4/15/98	5/11/98	26	250
				13DNB	Percent	Reduction 98
S001	246TNT		4/15/98	4/15/98	0	122641
S001	246TNT		4/15/98	5/11/98	26	377
				246TNT	Percent	Reduction 99
S001	24DNT		4/15/98	4/15/98	0	12500
S001	24DNT		4/15/98	5/11/98	26	250
				24DNT	--Percent	Reduction 98
S001	26DNT		4/15/98	4115198	0	13000
S001	260NT		4/15/98	5111198	26	260
				26DNT	Percent	Reduction 98
S001	2A46DT		4/15/98	4/15/98	0	8640
S001	2A46DT		4/15/98	5111198	26	250
				2A46DT	Percent	Reduction 97
S001	2NT		4/15/98	4/15/98	0	12500
S001	2NT		4/15/98	5111198	26	250
				2NT	Percent	Reduction 98
S001	3NT		4/15/98	4/15/98	0	12500
S001	3NT		4/15/98	5/11/98	26	250
				3NT	Percent	Reduction 98
S001	4A26DT		4/15/98	4/15/98	0	15273
S001	4A26DT		4/15/98	5/1 1/98	26	250
				4A26DT	Percent	Reduction 98
S001	4NT		4/15/98	4/15/98	0	12500
S001	4NT		4/15/98	5111198	26	250
				4NT	Percent	Reduction 98
S001	HMX		4/15/98	4/15/98	0	155725

Windrow	Compound	Construction Date	Date Monitored	Age (Days)	Avg. Conc. (UG/KG)
S001		4/15/98	5/11/98	26	2096
			HMX	Percent	Reduction 96
S001	NB	4/15/98	4/15/98	0	13000
s001	NB	4/15/98	5/11196	26	260
			NB	Percent	Reduction 96
S001	PETN	4/15/98	4/15/98	0	12500
s001	PETN	4/15/98	5/11/98	26	250
			PETN	Percent	Reduction 96
soot	RDX	4/15/98	4/15/98	0	1215500
s001	RDX	4/15/98	5/11/98	26	993
			RDX	Percent	Reduction 99
s001	TETRYL	4/15/98	4/15/98	0	32500
soot	TETRYL	4/15196	5/11/98	26	650
			TETRYL	Percent	Reduction 96

APPENDIX I
FIELD PRECISION SUMMARY

TABLE OF CONTENTS

DESCRIPTION **PAGES**

Table of RPD of Field Duplicates . . . 1 page

RELATIVE PERCENT DIFFERENCE OF FIELD DUPLICATES

Site ID	BIO-S001-00-09-1					BIO-S001-26-05-3				
Units	UG/KG				%	UG/KG				%
Compound	Sample		Duplicate		RPD	Sample		Duplicate		RPD
135TNB	12500.000	U	12500.000	U	0.00	250.000	U	250.000	U	0.00
13DNB	12500.000	U	12500.000	U	0.00	250.000	U	250.000	U	0.00
246TNT	178000.000		210000.000		16.49	457.000	P	575.000		22.87
24DNT	12500.000	U	12500.000	U	0.00	250.000	U	250.000	U	0.00
26DNT	13000.000	U	13000.000	U	0.00	260.000	U	260.000	U	0.00
2A46DT	9010.000	J	6680.000	J	29.70	250.000	U	250.000	U	0.00
2NT	12500.000	U	12500.000	U	0.00	250.000	U	250.000	U	0.00
3NT	12500.000	U	12500.000	U	0.00	250.000	U	250.000	U	0.00
4A26DT	28500.000	P	13400.000	P	72.08	250.000	U	250.000	U	0.00
4NT	12500.000	U	12500.000	U	0.00	250.000	U	250.000	U	0.00
HMX	247000.000		225000.000		9.32	2200.000	U	2200.000	U	0.00
NB	13000.000	U	13000.000	U	0.00	260.000	U	260.000	U	0.00
PETN	12500.000	U	12500.000	U	0.00	250.000	U	250.000	U	0.00
RDX	1840000.000		1790000.000		2.75	1000.000	U	887.000	PJ	11.98
TETRYL	32500.000	U	32500.000	U	0.00	650.000	U	650.000	U	0.00

Data Qualifiers:

U = Not Detected

J = Estimated value below quantitation limit

P = Greather than 25% difference on secondary confirmation column

UG/KG = Micrograms/Kilogram