N00164.AR.000302
NSWC CRANE
5090.3a

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

IN REPLY REFER TO:
5090
Ser 095/7195
21 OCT 1997
10-1-1997

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 Interim Progress Report for Solid Waste Management Unit (SWMU) 33/00 - Bioremediation Facility Pilot Scale Clean Soil Testing as enclosure (1). Enclosure (2) is the required certification statement.

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

Sincerely,

M. HUNSICKER
Director, Environmental Protection Department
By direction of
the Commander

Encl:
(1) Interim Progress Report for SWMU 33/00
(2) Certification Statement

Copy to:
→ADMINISTRATIVE RECORD
COMNAVSEASYSCOM (SEA OOT) (w/o encls)
IDEM (Stephanie Riddle)
MK (Dave 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.

SIGNATURE

JAMES M. HUNSICKER
Director, Environmental Protection Department
~~By direction of~~
~~the Commander~~
TITLE

21 OCT 1997
DATE

Enclosure (2)

Interim Progress Report
SWMU - 33/00, Bioremediation Facility
Pilot Scale Clean Soil Testing

NSWC Crane
Crane, Indiana

Unit Identification Code: N00164
Contract No. N62467-93-D-1106

October 1997
Revision 0

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

RESPONSE TO:

Comments on the draft Interim Progress Report for the Pilot Scale Clean Soil Testing
Naval Surface Warfare Center

Commenter: Carol Witt-Smith, Region 5, U.S. EPA

1. Page 1-1, Section 1.1, Sentence 2

   Comment: Change "...for as long as 60 days." to be the same as the text in the approved Ops Work Plan.

   Response: Page 1-1, Section 1.1 has been revised to include text as described in the Ops Plan.

2. Page 1-1, Section 1.2, Sentence 3

   Comment: Change "...obtaining the waste..." to "...obtaining concentrated waste...".

   Response: "...obtaining the waste..." has been revised to "obtaining concentrated waste...".

3. Page 2-1, Section 2.2, Par. 2, Sentence 1

   Comment: Change "...oxygen readings..." to "...oxygen testing...".

   Response: This sentence has been moved to Page 3-3, Section 3.2, Para 1, third from last sentence and "...readings..." was revised to "...testing...".

4. Page 3-3, Section 3.2, Under Very Good

   Comment: Add language to explain that the temperatures were brought down by timely contingency actions so that the high consistent temperatures so not mean that the temperatures will be killing the bacteria. Otherwise the contradicts the work plan that states you should have a optimum maximum of 60 degrees C.

   Response: Additional text has been added to clarify Page 3-3, Section 3.2, Par. VG.

5. Page 3-5, Section 3.3.7

   Comment: Move this line to the next page.

Response: Page 4-2, Mix 5 text has been revised to include comment.

11. Page 4-2, Mix 7A

Comment: Indent the word "in".

Response: Paragraph indentation has been corrected.

Comment: Expand the context of spring months affecting ambient temperatures.

Response: Text has been added for discussion of ambient temperatures effects.

12. Page 4-2, Mix C

Comment: Change this text. You are selecting manure types that are the same as the Umatilla Mix, but the ratios are different to make up for the loss of nutrients from alfalfa. And, the straw is meant to replace the alfalfa and sawdust bulking agents. Basically, the original Mix C performed well with chicken manure only. You are trying to see if adding cow manure would help in degradation. Mix 7B will show if the chicken does well on its own.

Response: Text has been revised to provide additional details.

13. Page 4-3, Table 4-2

Comment: Modify the table to list the Mixes identified in this cover letter.

Response: Table 4-2 has been revised to reflect mixes as specified in cover letter.

Comment: SOUTHDIV and NSWC requested the addition of Mix 3 and Mix 7A due to cost reductions.

Interim Progress Report
SWMU - 33/00, Bioremediation Facility
Pilot Scale Clean Soil Testing

NSWC Crane
Crane, Indiana

Unit Identification Code: N00164
Contract No. N62467-93-D-1106

October 1997
Revision 0

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

Interim Progress Report
SWMU - 33/00, Bioremediation Facility
Pilot Scale Clean Soil Testing

NSWC Crane
Crane, Indiana

October 3, 1997
Revision 0

CONTRACT N62467-93-D-1106
DELIVERY ORDER #0009
STATEMENT OF WORK #007

Prepared for

SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
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Don J. Miller
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9/30/97
Date

APPROVALS:

R. E. Hlavacek
Program Manager

10/10/97
Date

EXECUTIVE SUMMARY

This Interim Progress Report has been prepared by Morrison Knudsen (MK) for the Naval Facilities Engineering Command (NAVFACENGCOM), Southern Division pursuant to the scope of work defined in Delivery Order #0009, under Contract #N62467-93-D-1106. All remedial actions and interim measures taken at the Solid Waste Management Unit (SWMU) -33/00, located south of the Burns City Gate, near the Naval Surface Warfare Center (NSWC Crane) Landfill, Crane, Indiana, were performed in response to the Resource Conservation and Recovery Act (RCRA) Part B Permit for NSWC Crane.

This interim progress report summarizes the clean soil Pilot Scale Operation at the NSWC Crane Bioremediation Facility from June 28, 1997 through July 29, 1997.

The primary objective of the clean soil pilot scale testing was to verify which recipes provide an optimum environment for aerobic growth and hence reach and maintain the proper temperature levels for explosives contaminated soil degradation. Based on the clean soil results, recipes will be selected, mixed with explosives contaminated soil and composted for 60 days.

Based on previous explosives contaminated soil composting programs, bench scale testing, and Dewars Test results, eight recipes were selected for pilot scale clean soil testing. The pilot scale composting of clean soil using the selected recipes was performed during the period of June 28, 1997 and July 29, 1997. Pilot scale composting was performed for 30 days in order to evaluate the process parameters: temperature, moisture, oxygen, pH, Total Organic Carbon (TOC), and Total Kjeldahl Nitrogen (TKN). Monitoring of each parameter was performed consistent with the approved Pilot Scale Operational Plan (PSOP) (MK, 1997a) and Quality Assurance Project Plan (QAPP) (MK, 1997b).

Seven of the eight recipes were mixed and composted for 30 days. One recipe (Mix 1) was not performed due to difficulty in obtaining the required concentrated waste water treatment plant sludge. Five Mixes (3,5, 6, 7B, and 7C) met or exceeded the temperature objective of maintaining 55°C for two weeks. However, Mixes 2 and 4 showed high moisture levels, through the first two weeks of composting, as well as low oxygenation ratings which may have limited microbial growth.

An additional recipe was considered in the pilot scale clean soil testing was identified as Mix 7A which was used during the "Dry Run" testing in March and April of 1997. Mix 7A did not meet the temperature objective, but was tested during the period where ambient temperatures were as low as -3°C.

There were significant moisture level fluctuations due to the high rate of evaporation during the dry summer period of operation. During the last two weeks of operation large quantities of water were added to bring the moisture levels to within the desired range. Operating procedure modifications have been instituted in order to prevent low moisture levels in future operations.

Oxygen levels varied significantly and were measured at higher levels with two or more passes of the windrow machine during each turning event. All mixes showed improved oxygen levels with multiple passes. Mix 2 had the lowest oxygenation rating and was the most dense and difficult to mix recipe.

Based on the clean soil test and the previous dry run test, the objectives of the pilot scale clean soil operation have been accomplished. Upon review of the test data, seven final recipes have been selected to be tested in the pilot scale contaminated soil operation. These recipes are Mixes 1, 3, 4, 5, 7A, 7B, and 8 (a new recipe which is Mix 7C altered for the addition of cow manure).

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ACRONYMS

ABG	Ammunition Burning Ground
ACGIH	American Conference of Governmental Industrial Hygienists
APR	air purifying respirator
CAAA	Crane Army Ammunition Activity
C:N	carbon to nitrogen ratio
DOD	Department Of Defense
EPA	U. S. Environmental Protection Association
EPD	NSWC Crane Environmental Protection Department
FCR	Field Clarification Request
HEPA	High Efficiency Particulate Air
HMX	cyclotetramethylenetetranitramine
mg/kg	milligrams per kilogram
MK	Morrison Knudsen Corporation
NAVFACENGCOM	Naval Facilities Engineering Command
NH_3	ammonia
NSWC	Naval Surface Warfare Center
OV	organic vapor
PEL	permissible exposure limit
PID	photo-ionization detector
PMS	percent moisture at saturation
POTW	publicly owned treatment works
PPE	personnel protective equipment
ppm	parts per million
PSOP	Pilot Scale Operational Plan
QAPP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RDX	cyclonite
SSHP	Site Safety and Health Plan
SOP	Standard Operating Procedure
SWMU	Solid Waste Management Unit
TCLP	Toxicity Characteristic Leaching Procedure
TKN	total Kjeldahl nitrogen
TNT	trinitrotoluene
TOC	total organic carbon
UMDA	Umatilla Depot Activity
U. S. EPA	United States Environmental Protection Agency

WES	Waterways Experiment Station
WHC	water holding capacity

1.0
INTRODUCTION

The Naval Surface Warfare Center (NSWC) Crane, located in southwestern Indiana, provides support for equipment, shipboard weapons systems, and ordnance. In addition, NSWC supports the Crane Army Ammunition Activity (CAAA) including production and renovation of conventional ammunition, storage, shipment, and demilitarization and disposal of conventional ammunition.

The Department of Defense (DOD) has utilized bioremediation, or composting, to treat explosives contaminated soil since 1982 at a number of sites throughout the country. Bioremediation has proven to be successful in degrading explosive contaminants including trinitrotoluene (TNT), cyclonite (RDX), cyclotetramethylenetetranitramine (HMX), Tetryl, and nitrocellulose in soils and sludges at other sites. (Weston, 1993, U.S. EPA, 1993a, 1993b). Based on these previous successes, the preferred treatment alternative for explosive contaminated soils from the Ammunition Burning Ground (ABG), Rockeye, Mine Fill A, and Mine Fill B Solid Waste Management Units at NSWC Crane is on-site bioremediation. Bioremediation of contaminated soil is preferred due to its ability to treat material on-site with limited transportation, lower costs, and high treatment efficiency.

A pilot demonstration test was performed to evaluate the effectiveness of various compost recipes suitable for degrading explosive contaminated soil and to provide operational and process information necessary to select the optimal recipes for the pilot scale contaminated soil tests. This pilot study represents one aspect of the overall pilot scale bioremediation testing program. Results of the study will provide the basis for contaminated soil pilot scale testing. This report details the results of the clean soil pilot scale operations performed at the NSWC Crane Bioremediation Facility from June 28, 1997 through July 29, 1997 per the approved Pilot Scale Operational Plan (MK, 1997a) and Quality Assurance Project Plan (MK, 1997b).

1.1 OBJECTIVES

The primary objective of the clean soil pilot scale testing was to determine which recipes provide an optimum environment for microorganism growth and degradation of explosives contaminated soil. Based on the clean soil results, recipes deemed conducive to support biodegradation will be selected, mixed with explosives contaminated soil and composted for 60 days. The total length of time for the pilot scale test clean soil composting was 30 days and contaminated soil composting is anticipated to be 60 days. Should a contaminated soil pile reach all the performance goals prior to completing the 60 day period, that pile may be considered successful and the U.S. Navy, in coordination with the U.S. EPA, may decide to end the treatment process sooner for that particular successful pile.

A secondary objective of the clean soil pilot scale testing was to verify field standard operating procedures and identify improvements in operations where necessary. Towards this objective, all operations, except for off-site analytical laboratory activities, were performed simulating explosives contaminated soil conditions.

1.2 RECIPE SELECTION

Based on previous explosives contaminated soil composting programs, bench scale testing, and Dewars Test results, eight recipes were selected and composting of clean soil was performed between June 28, 1997 and July 29, 1997 as specified in the approved PSOP and QAPP. Seven of the eight recipes were generated and treated for 30 days. Recipe Mix 1 was not used due to difficulty in obtaining the required concentrated waste water treatment plant sludge.

In March of 1997, preliminary tests ("Dry Run" tests) were performed prior to the bioremediation facility construction completion. From the preliminary tests, a ninth recipe, identified as Mix 7A, has been selected for comparison purposes due to its low cost and desired temperature profiles. Mix 7A consisted of 3.2% chicken manure, 71.8% straw, and 25% clean soil. The data available from the preliminary tests is discussed in Section 3.0 of this report. The Dry Run Test report is provided in Appendix A. The nine clean soil test recipes considered are listed in Table 1-1.

TABLE 1-1
PILOT SCALE CLEAN SOIL WINDROW RECIPES

Amendment (in percent)	Mix								
	1	2	3	4	5	6	7A	7B	7C
POTW Sludge	25.00								
Alfalfa	25.00		25.00	19.25	19.25	15.00			
Sawdust	12.50			19.25	19.25	10.00			
Wood Chips	12.50	40.00	25.00			10.00			
Soil	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Turkey Manure			25.00		25.75	25.00			
Chicken Manure		35.00		3.25			3.50	15.00	10.00
Cow Manure				22.50					
Vegetable Waste				10.75	10.75	15.00			10.00
Straw							71.50	60.00	65.00
Total	100	100	100	100	100	100	100	100	100

* Mix 7A was performed in March and April 1997.

2.0
OPERATIONS AND MAINTENANCE

2.1 WINDROW FORMATION

In order to evaluate the recipes selected, seven windrows measuring approximately 18 feet wide, 25 feet long and 6 feet high were formed. The windrows varied in size due to the difference in amendment selection and densities between recipes. Mixes 2, 4, 7A and 7B were formed in building 3 while Mixes 3, 5, and 6 were formed in building 2. Each windrow formation was performed as specified in the approved PSOP. Amendment mixing proceeded as specified using the front end loader and mixer/grinder unit; however, utilizing the weight system on the mixer/grinder unit as a method of measuring amendment quantities was found to be inappropriate. The wide variation in moisture content of the amendments introduces errors in the formation of recipes when weight is the unit of measurement. All recipes were measured on a volumetric basis with both weights and volumes being recorded on the Record of Recipe form. The completed Record of Recipe Forms are provided in Appendix B. Each windrow was mixed and formed with a minimum of two passes of the Scarab® windrow turner.

2.2 PROCESS MONITORING AND ADJUSTMENTS

The PSOP, QAPP, Standard Operating Procedures (SOPs), and Site Safety and Health Plan (SSHP) were closely followed throughout the clean soil tests. Based on initial operational experience and sampling results, operational and process adjustments were instituted to improve operation efficiencies and process results.

Due to the consistency and texture of the mixes, the use of a push tube and split spoon for compost sample extraction was ineffective and a hand auger sampler was used. Additional process monitoring adjustments are described in Section 3.0. Field Clarification Requests (FCRs) have been issued for modifications and alterations to the PSOP, QAPP, SSHP, and the various SOPs. All FCRs will be resolved prior to beginning the contaminated soil operation.

2.3 SAFETY AND HEALTH CONCERNS

During initial clean soil start-up, Level C personnel protective equipment (PPE) was selected due to the nature of activities and potential contaminant levels. Level C consisted of 16 inch high polyvinyl chloride (PVC) boots, dedicated coveralls, inner and outer nitrile gloves, standard Tyvek ® coveralls, goggles and a half-mask air purifying respirator (APR) with organic vapor/high efficiency particulate air (OV/HEPA) cartridges. During amendment handling and mixing of compost piles, it was observed that excessive ammonia (NH_3) odor was being generated by the chicken and turkey manure.

Personnel air monitoring was performed for NH_3 and the test results indicated localized NH_3 concentrations as high as 200 parts per million (ppm) which was above the Permissible Exposure Limit (PEL) of 50 ppm. Respirator protection was upgraded to half-mask NH_3/HEPA cartridges, however, the NH_3 gas was causing excessive tearing of the eyes and the respirator protection was upgraded to full-face APR with NH_3/HEPA cartridges.

After 3 to 5 days, NH_3 levels dropped below the PEL and then slowly dropped to 1-10 ppm and non-detect by the end of the compost cycle (30-days). PPE was downgraded to disposable dust masks when NH_3 levels were consistently recorded below the PEL. Disposable dust masks were selected because only nuisance particulate dust respiratory protection was necessary. This decision was supported by real time dust/aerosol monitoring which indicated maximum dust concentrations of 1.2 mg/m^3 during windrow turning (worst case). Maximum dust/aerosol concentrations measured during screening was

approximately 1 mg/m^3. The PEL for inert or nuisance dust (total dust) is 15 mg/m^3. MK uses a 10 mg/m^3 total dust occupational exposure limit based on guidance from the American Conference of Governmental Industrial Hygienists (ACGIH).

Total organic vapor concentrations obtained during composting using a direct reading photo-ionization detector (PID) instrument ranged from 10-15 ppm PID equivalents. Colorimetric indicator tube monitoring inside of the compost structure indicated no detectable levels of formaldehyde, benzene, acetone, petroleum distillates, toluene, dichloromethane, nitrogen dioxide, nitrous fumes, hydrogen sulfide, carbon monoxide, and vinyl chloride. Carbon dioxide levels were equivalent to normal atmospheric levels.

In addition, a TMX-412 direct reading multi-gas meter was used to monitor atmospheric oxygen, carbon monoxide, hydrogen sulfide, and methane. Oxygen levels remained in normal range and no detectable levels of hydrogen sulfide, carbon monoxide, and methane were obtained using this instrument.

Basic sound level monitoring was performed during all work activities. In general, all equipment during operation requires personnel in near vicinity to use hearing protection devices based on sound levels exceeding 85 dBA within 15 foot radius of equipment. Operators of all "cab enclosed" equipment do not require hearing protection. All measured sound levels were below 85 dBA except for near the SCARAB® windrow turning machine.

Bioaerosol sampling was performed on the first three days into the compost cycle. Samples were obtained for total bacteria and total fungi (molds and yeast) both inside of the compost structure and outside (representing background). Pre-selected bacteria culture plates were subcultured for *E.coli*. None was detected. Fungi (molds and yeast) culture plates were checked for *Aspergillus fumagatus*, none was detected. The predominant species detected in all air sample plates, both bacteria sample plates and fungi (molds and yeast) sample plates were *Penicillium*, *Alternaria*, and *Cladosporium*. These species are molds normally found in the atmosphere. For the median concentrations obtained, there was no indication of a potential health threat to workers from bioaerosols. The bioaerosol sampling campaign will also be conducted during the contaminated soil operation. A detailed bioaerosol sampling report will be provided at the completion of the pilot scale operations.

Initial physiological monitoring for heat stress indicated a week to 10 days was necessary for worker acclimatization. In addition, certain personnel responded differently to the same heat loading. Prior to PPE downgrades, significant heat stress was indicated by worker pulse rate, core temperature and various heat disorder physiological symptoms. After PPE downgrades, minimal heat stress was indicated. However, in addition to PPE downgrades, ice vest use was mandatory when ambient temperature were above 90°F or when excessive work load was anticipated.

Based on initial operating experiences and monitoring results PPE downgrades were instituted. This helped to minimize heat stress conditions incurred by workers on selected tasks. Ammonia off-gas was observed to be the predominant airborne chemical hazard due to the recipes including significant ratios of chicken/turkey manure to other amendments. The ammonia off-gas necessitated the respiratory protection upgrade during initial pile formation and composting.

3.0
DATA REVIEW AND ANALYSIS

Previous composting experience and research has shown that the process parameters essential to successful biodegradation of the explosive contaminants are temperature, moisture, oxygen, pH, and carbon to nitrogen ratio (C:N). These parameters were measured and monitored as described in the approved PSOP and QAPP. In addition, the recipe texture was monitored due to its influence on the process parameters and for aiding the review of the parameter monitoring results. All in-situ measurements (i.e., temperature, oxygen level) were taken prior to removing sample material for other measurements or analyses so as not to disturb the compost pile and potentially bias the in-situ measurement. Adjustments to the process for temperature, oxygen, and moisture were performed depending on the monitored results. The adjustments were made based on predetermined contingency process methods discussed in Section 8.0 of the PSOP.

3.1 TEXTURE

Texture of the compost material has significant influence on the process parameters, i.e., moisture content, oxygen content, and temperature. If the final amendment and soil mix is too dense, bulking of the material does not occur and oxygen levels may be too low to sustain high bacteria growth which results in lower temperatures and lowered explosive degradation rates. If the final mix is extremely high in bulking agents, such as straw, wood chips, or alfalfa, the mix may be "stringy" or "clumpy". Thorough mixing of the recipe does not occur and results in a nonhomogeneous mass that may be difficult to sample. Non-homogeneity may reduce degradation of explosives because optimum conditions for the moisture and nutrients may not be available for microbial growth. In order to provide comparison between recipes, the following categories of texture were used to classify and grade each mix at the initiation, mid-cycle, and end of cycle conditions.

- VG (Very Good)
  The mixture is well mixed and appears to be very homogenous. There is minimal or no clumping of materials. The mix appears to be uniformly moist and samples are easily collected.

- G (Good)
  The mixture is well mixed, appears to be homogenous with minor clumping, uniformly moist, and samples are fairly easily collected.

- A (Average)
  The mixture is fairly well mixed with some segregation, noticeably high level of fines or significant clumping with noticeable moisture differences (spots of wet and dry areas). Sample collection may become more difficult.

- P (Poor)
  The mixture is difficult to turn. It is not very well mixed and exhibits signs of segregation or increased density. Clumping may be highly visible and wet and dry spots are easily identified. Sample collection may be very difficult.

3.1.1 Mix 2 Texture

The results of the initial Mix 2 mixing of amendments yielded a very moist clumpy non-homogeneous product. The amendments were discharged from the grinder/mixer in 10 inch diameter and larger size lumps due to its very dense, sticky and difficult to handle characteristics. Ammonia vapors were present in excess of 100 ppm in the immediate area of the windrow causing impacts to health and safety. As soil

was added and the mixture turned with the windrow machine, the consistency improved, but the mixture continued to appear very dense when compared to other mixes. At day 15 the consistency continued to improve but as the moisture level dropped, the wood chips appeared to segregate from the chicken manure. At day 26 the wood chips were very prominent at the surface and segregation was evident. Below the surface, the soil and chicken manure mix appeared very fine and varied from dry to moist. Based on these observations, the overall texture rating of Mix 2 is A.

3.1.2 Mix 3 Texture

The results of the initial mixing of amendments yielded a well mixed, moist product. The material appeared homogeneous and fluffy. As soil was added, the mixture changed very little and remained homogeneous. At day 25, the wood chips were more prominent and appeared to be slightly segregated. The other material in the mix was very fine and slightly moist. Based on these observations, the overall texture rating of Mix 3 is G.

3.1.3 Mix 4 Texture

The results of the initial mixing of amendments yielded a well mixed, moist product. The material appeared to be homogeneous and fluffy. Odor of potato waste and ammonia was evident but not severe. As soil was added, the mix appeared to remain homogeneous. At day 25, the mix was much finer, moist, and remained homogeneous. Based on these observations, the overall texture rating of Mix 4 is VG.

3.1.4 Mix 5 Texture

The results of the initial mixing of amendments yielded a well mixed, moist product. The material appeared to be homogeneous and fluffy. As soil was added, the mix appeared to remain homogeneous. At day 25, the mix was much finer, moist, and remained homogeneous. Based on these observations, the overall texture rating of Mix 5 is VG.

3.1.5 Mix 6 Texture

The results of the initial mixing of amendments yielded a well mixed, moist product. The material appeared to be homogeneous and fluffy. As soil was added appearance remained homogeneous and moist. At day 25, the mix was very fine, moist, and remained homogeneous. Wood chips were evident but not prominent or segregated. Based on these observations, the overall texture rating of Mix 6 is VG.

3.1.6 Mix 7A Texture

Mix 7A texture data was not available from the "Dry Run" report performed in April 1997, however, based on the recipe being similar to Mix 7B, the overall texture rating of Mix 7A is estimated to be VG.

3.1.7 Mix 7B Texture

The results of the initial mixing of amendments yielded a well mixed, extremely fluffy, and slightly dry product. The material appeared to be homogeneous. Odor of ammonia was evident but not severe. As soil was added the mix appearance remained homogeneous. The mix was very difficult to sample and probe during the middle stages of composting. At day 25, the mix was moist, and remained homogeneous. Straw was prominent but not segregated. Sampling and probing improved with additional passes of windrow. Based on these observations, the overall texture rating of Mix 7B is VG.

3.1.8 Mix 7C Texture

The results of the initial mixing of amendments yielded a well mixed, extremely fluffy, and slightly dry product. The material appeared to be homogeneous. Odor of ammonia was evident but not severe. As soil was added appearance remained homogeneous. Very difficult to sample and probe during middle stages of composting. At day 25, the mix was moist, and remained homogeneous. Sampling and probing improved with additional passes of windrow. Based on these observations, the overall texture rating of Mix 7C is VG.

Based upon the results of texture observations, Mixes 3, 4, 5, 6, 7A, 7B and 7C would appear to be more conducive to maintaining optimum bulking and aeration for enhancing biodegradation.

3.2 TEMPERATURE

Temperature is one of the most important monitoring parameters since it is a primary indicator of successful achievement of conventional thermophilic composting operations in the windrows. The normal thermal operating range for composting is from 25 to 65°C. Results of successful composting of explosives contaminated soil testing indicates the average pile temperature rises to 25 to 40°C within the first few days of formation, continues rising to within the temperature range of 40 to 65°C, and maintains that temperature range for at least two weeks provided adequate moisture, nutrients, and oxygen are available. Based on conventional composting practice, such temperatures indicate a healthy, metabolically active windrow. The process goal was to maintain the average windrow temperature near 55°C. Temperature decrease over time below 50°C is viewed as an indicator of a pile that is nearing the end of its operation (Weston, 1993). Temperature measurements were recorded before and after each windrow turning event, however, Mixes 4, 7B, 7C, and 5 were generated late on day 0 and did not receive post turn temperature and oxygen testing until the following day. Temperature profiles provided in Appendix C show the monitoring results of the average pre- and post-turn measurements. The graphs have been annotated with process adjustments which may cause a fluctuation in temperatures such as water addition and number of windrow machine passes per turning event.

In order to provide comparison between recipes, the following categories of temperature will be used to classify and grade each mix at the initiation, mid-cycle, and end of cycle conditions.

- VG
  The mixture exhibits a rapid temperature increase to 40°C within two days. Temperatures continue to rise above 55°C and maintain for approximately two weeks. Temperatures often exceed 65°C but are readily reduced with aeration and/or moisture addition to within the optimum operating range.

- G
  The mixture exhibits temperatures of 40 to 50°C within five days. Temperatures continue to rise to 55°C, are maintained for two weeks, and may exceed 60°C occasionally.

- A
  The mixture exhibits temperatures of 40 to 50°C within seven days. Temperatures of 55°C are not maintained for two weeks and rarely or never exceeds 60°C.

- P
  The mixture does not exhibit temperatures of 50°C within ten days. Temperatures do not rise to 55°C and are not maintained.

3.2.1 Mix 2 Temperature

The initial average pre-turn temperatures of Mix 2 increased to above 40°C during the first day of formation. Average pre-turn temperatures continued to increase above 55°C within 5 days and only maintained 55°C or higher for 6 days. The maximum average pre-turn temperature was 58.5°C. The remaining average temperatures fluctuated between 45°C and 50°C. Based on the average pre-turn temperature profiles, the overall temperature rating of Mix 2 is A.

3.2.2 Mix 3 Temperature

The initial average pre-turn temperatures of Mix 3 increased to above 40°C during the first day of formation. Average pre-turn temperatures continued to increase above 55°C within 3 days and maintained 55°C or higher for 14 days with periods occasionally dropping to 51°C as moisture content was low. The maximum average pre-turn temperature was 61.88°C. Based on the average pre-turn temperature profiles, the overall temperature rating of Mix 3 is G.

3.2.3 Mix 4 Temperature

The initial average pre-turn temperatures of Mix 4 increased to above 40°C during the first day of formation. Average pre-turn temperatures only increase above 55°C only occasionally (four non-consecutive days). The maximum average pre-turn temperature was 58.33°C. Based on the average pre-turn temperature profiles, the overall temperature rating of Mix 4 is A.

3.2.4 Mix 5 Temperature

The initial average pre-turn temperatures of Mix 5 increased to 40°C during the first day of formation. Average pre-turn temperatures continued to increase above 55°C within 4 days, and maintained 55°C or higher for 17 days with periodic drops as low as 52°C due to low moisture. The maximum average pre-turn temperature was 60.58°C. Based on the average pre-turn temperature profiles, the overall temperature rating of Mix 5 is G.

3.2.5 Mix 6 Temperature

The initial average pre-turn temperatures of Mix 6 increased to above 40°C during the first two days of formation. Average pre-turn temperatures continued to increase above 55°C within 5 days, and maintained 55°C or higher for more than 20 days with an occasional drop to 52.33°C. The maximum average pre-turn temperature was 59.42°C. Based on the average pre-turn temperature profiles, the overall temperature rating of Mix 6 is G.

3.2.6 Mix 7A Temperature (from "Dry Run" tests)

This information was extracted from the "Dry Run Tests" performed in March and April of 1997. Ambient temperatures ranged from -3 to 22°C with the lowest temperatures experienced on days 0 and 1. The initial average pre-turn temperatures of Mix 7A increased to above 40°C during the first 9 days of composting. Average pre-turn temperatures continued to increase, however never reached 55°C. The maximum average pre-turn temperature was 54°C. Based on the average pre-turn temperature profiles, the overall temperature rating of Mix 7A is P, however, this temperature profile may be bias due to the colder ambient temperatures.

3.2.7 Mix 7B Temperature

The initial average pre-turn temperatures of Mix 7B increased to above 40°C during the first day of formation. Average pre-turn temperatures continued to increase above 55°C within two days and

maintained 55°C or higher for 16 days with three drops below 55°C when water was added. Repeatedly reached temperatures above 60°C. The maximum average pre-turn temperature was 66.92°C. Based on the average pre-turn temperature profiles, the overall temperature rating of Mix 7B is VG.

3.2.8 Mix 7C Temperature

The initial average pre-turn temperatures of Mix 7C increased to above 40°C during the first two days of formation. Average pre-turn temperatures continued to increase above 55°C within 4 days and maintained 55°C for more than 20 days except when water was added. Repeatedly reached temperatures above 60°C. The maximum average pre-turn temperature was 65.42°C. Based on the average pre-turn temperature profiles, the overall temperature rating of Mix 7C is VG.

Based upon the results of temperature monitoring, Mixes 3, 4, 5, 6, 7B and 7C would appear to be more conducive to maintaining optimum temperatures for enhancing biodegradation. Temperature readings throughout these piles were consistent and showed minimal variability and deviation. Mix 7A's temperature profile may be biased due to the colder ambient temperatures.

3.3 MOISTURE CAPACITY

Previous biodegradation studies performed indicated that effective microbial biodegradation occurred when the composting moisture content is 40 to 60% of the maximum water holding capacity (WHC) with the optimum condition being at 50 % WHC. If moisture levels are excessively lower or higher than this range, proper composting and explosives degradation may be impacted. Reduced moisture content will inhibit microbial movement and nutrient availability, while excessive moisture content will cause the moisture to fill the void spaces needed for proper aeration, thus reducing the oxygen level and aerobic microbial growth. At no time during the process was leachate observed from any of the mixes. Moisture level monitoring was performed three times per week. If moisture was added to the windrows, moisture levels were checked again after windrow turning. The average WHC data and graphs for each mixture is provided in Appendix D.

Due to high levels of evaporation during the composting cycle and a procedure restriction of 100 gallons water addition per day, the mixtures began to drop in moisture content. The surface of the piles became dusty during high wind periods. With NSWC Crane's Environmental Protection Department (EPD) concurrence, as much as 300 gallons per day were added to two piles in order to obtain the appropriate moisture levels. The moisture content of all Mixes was brought up to and maintained at approximately 50% maximum WHC. No further dust was evident through the remaining test period.

The percent of maximum WHC is the amount of water (in grams) retained in the mix sample compared to the maximum amount of water (in grams) retained in the mix sample without ponding or running (saturation). This measurement is independent of the type of amendments and proportions used within the mix and therefore, is not a good tool for comparing the moisture capacity of one mix to another due to the variation in materials and proportions. In order to provide a comparison between recipes, the Percent Moisture at Saturation (PMS) was used for comparing the various mixes as each mix retains a different moisture holding capacity which may change throughout the degradation process. The PMS is the ratio of the maximum amount of water (in grams) which can be retained in the mix sample without ponding (saturation) compared to the total weight of the mix sample at saturation. Those recipes with the higher PMS values are more desirable than those with lower values.

The following categories of moisture condition were used to classify and grade each mix at the initiation, mid-cycle, and end of cycle conditions.

- VG
  The mixture exhibits excellent moisture holding capabilities. The PMS consistently is greater than 50%.

- G
  The mixture exhibits good moisture holding capabilities. The average PMS is greater than 42% but less than 50%. May exceed 50% at times.

- A
  The mixture exhibits fair moisture holding capabilities. The average PMS is less than 42% but greater than 35%. May exceed 42% at times.

- P
  The mixture does not exhibit good moisture holding capabilities. The average PMS is less than 35%.

3.3.1 Mix 2 Moisture

550 gallons of water were required to be added to Mix 2 throughout the 30 day cycle in order to maintain optimum WHC conditions. The average PMS for Mix 2 throughout its cycle is slightly above 40% and therefore is rated A.

3.3.2 Mix 3 Moisture

900 gallons of water were required to be added to Mix 3 throughout the 30 day cycle in order to maintain optimum WHC conditions. The average PMS for Mix 3 throughout its cycle is slightly above 45% and therefore is rated G.

3.3.3 Mix 4 Moisture

400 gallons of water were required to be added to Mix 4 throughout the 30 day cycle in order to maintain optimum WHC conditions. The average PMS for Mix 4 throughout its cycle is slightly above 47% and therefore is rated G.

3.3.4 Mix 5 Moisture

1,000 gallons of water were required to be added to Mix 5 throughout the 30 day cycle in order to maintain optimum WHC conditions. The average PMS for Mix 5 throughout its cycle is slightly above 47% and therefore is rated G.

3.3.5 Mix 6 Moisture

750 gallons of water were required to be added to Mix 6 throughout the 30 day cycle in order to maintain optimum WHC conditions. The average PMS for Mix 6 throughout its cycle is slightly above 45% and therefore is rated G.

3.3.6 Mix 7A Moisture

530 gallons of water were added to Mix 7A throughout the Dry Run test cycle (33 days). The average PMS for Mix 7A is not available, however due to its similarity to Mix 7B, the average PMS is assumed to be similarly rated VG.

3.3.7 Mix 7B Moisture

Mid way through the composting cycle (July 11, 1997) Mix 7B became extremely difficult to sample and probe with the instruments due to low moisture content from moisture evaporation. Significant quantities of water were added and an increase in the number of windrow passes at each turning event alleviated the problem. Both conditions were corrected and are not expected to occur during the contaminated soil operation. 1,000 gallons of water were required to be added to Mix 7B throughout the 30 day cycle in order to maintain optimum WHC conditions. The average PMS for Mix 7B throughout its cycle is slightly above 56% and therefore is rated VG.

3.3.8 Mix 7C Moisture

700 gallons of water were required to be added to Mix 7C throughout the 30 day cycle in order to maintain optimum WHC conditions. The average PMS for Mix 7C throughout its cycle is slightly above 45% and therefore is rated G.

Based upon the results, Mixes 3, 4, 5, 6, 7A, 7B, and 7C would appear to be more conducive to maintaining optimum moisture conditions for enhancing biodegradation. Moisture data and profiles are provided in Appendix D and show the monitoring results of the average moisture measurements. The graphs have been annotated with process adjustments which may cause a fluctuation in moisture content such as water addition and number of windrow machine passes per turning event.

3.4 OXYGENATION

Typical compost oxygen levels for rapid degradation are greater than 5%; however, the preferred level is much greater than 5%. The desired operating range for aerobic activity is 5 to 20% oxygen content. If sufficient oxygen levels are not maintained, proper microbial degradation may not occur, and thermophilic temperatures would not be maintained. Oxygen levels decline rapidly to very low levels (less than 5%) in a short time after mixing. Oxygen levels of less than 1% indicate the process may approach anaerobic conditions, and aeration is required. Prior to July 12, 1997 (days 14 and 15) all post-turn oxygen and temperatures were monitored no less than one hour after turning as specified in the approved SOP. In order to obtain a more accurate indication of post-turn oxygen content, with U.S. Navy approval, the procedure was changed to perform oxygen monitoring as soon as practical after turning. Therefore, only the oxygen levels measured after July 12, 1997 are considered in the discussions below. The oxygen monitoring data and profiles are provided in Appendix E.

In order to provide comparison between recipes, the following categories of oxygenation will be used to classify and grade each mix at the initiation, mid-cycle, and end of cycle conditions. Oxygenation is affected by the density and bulking characteristics of the mix. The more dense the mix becomes the less oxygen is available for microorganism growth.

- VG
  The mixture exhibits an excellent oxygenation level. Levels of oxygen greater than 12% are indicated after two or three passes of the turning machine.

- G
  The mixture exhibits a good oxygenation level. Levels of oxygen greater than 8% are indicated after two or three passes of the turning machine.

- A
  The mixture exhibits a fair oxygenation level with some difficulty and irregularity in increasing oxygen levels. Levels of oxygen greater than 5% require three passes of the windrow machine.

- P
  The mixture does not exhibit very good oxygenation levels after three passes of the windrow machine. Levels of oxygen are less than 5% after three passes.

3.4.1 Mix 2 Oxygenation

The average post turn oxygen levels were recorded at less than 3% with two passes of the windrow turner and between 5 and 10% with three passes. The Oxygenation rating of Mix 2 is A.

3.4.2 Mix 3 Oxygenation

The average post turn oxygen levels were recorded from 1.88 to 14% with two passes of the windrow turner and between 7 and 11% with three passes. The Oxygenation rating of Mix 3 is G.

3.4.3 Mix 4 Oxygenation

The average post turn oxygen levels were recorded at less than 4% with two passes of the windrow turner and greater than 10% with three passes. The Oxygenation rating of Mix 4 is A.

3.4.4 Mix 5 Oxygenation

The average post turn oxygen levels were recorded at less than 5% with two passes of the windrow turner and between 3 and 12% with three passes. The Oxygenation rating of Mix 5 is A.

3.4.5 Mix 6 Oxygenation

The average post turn oxygen levels were recorded at less than 3% with two passes of the windrow turner and between 5 and 10% with three passes. The Oxygenation rating of Mix 6 is A.

3.4.6 Mix 7A Oxygenation

Based on the data extracted from the Dry Run tests performed in March and April of 1997, the average post turn oxygen levels were recorded at more than 6% and as high as 18 % during the periods measured. The number of windrow turner passes was not recorded. The Oxygenation rating of Mix 7A is estimated to be very similar to mix 7B and therefore is VG.

3.4.7 Mix 7B Oxygenation

The average post turn oxygen levels were recorded at more than 8% with one pass, greater than 17 % with two passes of the windrow turner and as high as 18% with three passes. The Oxygenation rating of Mix 7B is VG.

3.4.7 Mix 7C Oxygenation

The average post turn oxygen levels were recorded between 6 and 11% with two passes of the windrow turner and between 3 and 11% with three passes. The Oxygenation rating of Mix 7C is G.

Based upon the results, Mixes 3, 7A, 7B, and 7C would appear to be more conducive to maintaining optimum oxygen conditions for enhancing biodegradation. Oxygen data and profiles are provided in Appendix E and show the monitoring results of the average oxygen measurements. The graphs have been annotated with process adjustments which may cause a fluctuation in oxygen content such as number of windrow machine passes per turning event.

3.5 ECONOMICS AND AVAILABILITY

The benefit of economics cannot be realized without considering the recipe's effectiveness at remediating the contaminated soil. The cost and availability rating may be misleading without knowing the explosives recipe degradation rates and effectiveness. A higher cost recipe may degrade explosives much quicker than a lower cost recipe thus, reducing operational time and overall costs. The economics of each recipe will be considered during the selection of the full scale recipe at the end of the contaminated soil pilot scale tests. The following economic and availability information is provided for information.

TABLE 3-1
MIX ECONOMICS AND AVAILABILITY

MIX	$ PER TON*	AVAILABILITY
2	$14.82	readily available
3	$16.60	usually available
4	$24.49	usually available
5	$22.36	usually available
6	$25.54	usually available
7A	$7.17	readily available
7B	$8.94	readily available
7C	$16.78	readily available

* All costs are based on actual delivered rates and known rate increases at the time of this report.

3.6 pH LEVEL MONITORING

It was anticipated, based on experience at Umatilla Depot Activity (UMDA), Waterways Experiment Station (WES), and conventional composting practices that the pH operating range is between 5.5 and 9.0. The pH would steadily increase from near neutral to a level as high as 8.8 within weeks of operation and then decrease to a level between 7 and 8. Levels of pH were not adjusted during treatment. Acidic pH values below 5.5 would have been alleviated by the aeration and increased oxygenation to avoid anaerobic conditions and acid formation. Reintroduction or alterations of amendments for the purpose of pH adjustment was not performed.

Samples for pH level monitoring were collected at location #1 for each of the four cross-sections, once per week, prior to turning, as described in the approved PSOP. Samples from Mixes 4, 5, and 6 resulted in a pH less than 7 within the first week of pile formation and steadily increased to as high as 8.69 pH. These three mixes contained more than 10% by volume potato waste amendment which was observed to give off a slight vinegar odor upon delivery. This may account for the slightly acidic condition at initial formation. Samples from the remaining mixes resulted in pHs from 7.43 up to 8.88. All pH samples were within the operating range specified in the approved PSOP. Results of the pH sampling are provided in Appendix F.

3.7 TOC/TKN LEVEL MONITORING

Carbon and nitrogen are the primary nutrient sources for microbial growth. Data has shown that typical composting operations for municipal and yard wastes are highly efficient when the C:N ratio is near or at the optimum 30:1 proportions. Total organic carbon (TOC) and total Kjeldahl nitrogen (TKN) levels were monitored for the purpose of tracking the C:N ratio during the composting process. The C:N ratio was not intended to be adjusted. Reintroduction or alterations of amendments for the purpose of TOC or TKN adjustment were not performed. Average C:N ratios are listed below and results of the TOC and TKN sampling are provided in Appendix G.

3.7.1 Mix 2 C:N

The initial average C:N was 6.5 which indicates high nitrogen content due to the high percentage of chicken manure and resulted ammonia vapors as high as 100 ppm to emit during the early stages of formation and composting. Ammonia vapors as high as 200 ppm were recorded at the chicken manure storage area. The C:N decreased slightly to 6.0 on day 10, decreased to 3.5 on day 20, and increased to 8.4 by day 30.

3.7.2 Mix 3 C:N

The initial average C:N was 9.2 which indicates high nitrogen content due to the high percentage of alfalfa and turkey manure. The C:N increased to 12.2 on day 10, decreased to 10.6 on day 20, and decreased slightly to 10.4 by day 30.

3.7.3 Mix 4 C:N

The initial average C:N was 27.9 which indicates very good proportions of amendments which approaches the 30:1 optimum condition. The C:N decreased to 14.7 on day 10, 13.0 on day 20, and increased slightly to 16.4 by day 30.

3.7.4 Mix 5 C:N

The initial average C:N was 14.8 which indicates high nitrogen content due to the high percentage of alfalfa and turkey manure. The C:N decreased to 11.5 on day 10, increased slightly to 12.1 on day 20, and increased to 14.4 by day 30.

3.7.5 Mix 6 C:N

The initial average C:N was 10.8 which indicates high nitrogen content also due to the high percentage of alfalfa and turkey manure. The C:N increased to 13.5 on day 10, decreased to 10.2 on day 20, and increased to 15.4 by day 30.

3.7.6 Mix 7A C:N

The initial average C:N was 71 which indicates low nitrogen content due to the low percentage of chicken manure. The C:N decreased to 31 on day 7, decreased to 16 on day 20, and remained constant at 16 to day 30.

3.7.7 Mix 7B C:N

The initial average C:N was 8.2 which indicates high nitrogen content due to the high percentage of chicken manure. The C:N increased to 9.7 on day 10, decreased to 7.9 on day 20, and increased slightly to 10 by day 30.

3.7.8 Mix 7C C:N

The initial average C:N was 11 which indicates high nitrogen content due to the high percentage of chicken manure. The C:N decreased to 8.0 on day 10, decreased to 7.3 on day 20, and increased slightly to 8.9 by day 30.

3.8 AMBIENT TEMPERATURE AND HUMIDITY MONITORING

The ambient temperature and relative humidity were monitored daily as described in the approved PSOP. Average daily ambient temperatures ranged between 20 and 28°C with the average daily relative humidity varying from 67 to 92 percent. Results of the ambient temperature and humidity monitoring are provided in Appendix H.

4.0
CONCLUSIONS AND RECOMMENDATIONS

For summarizing the recipe performance ratings, the ratings were assigned a value based on 1 being the most desirable or Very Good and 4 being mo t undesirable or Poor. Each criteria has been assigned a weighting based on the level of criticality each particular criteria is to the composting activity, i.e., temperature being the most important indicator of biological activity, moisture being second, and texture and oxygen being third. The various categories are totaled for each recipe. The Table 4-1 lists the recipes, the criteria and its weighting, and the total weighted rating (the lower total rating being the most desirable and the highest total rating being the most undesirable).

Mix 2 Mix 2 presents the most undesirable recipe of those tested with clean soil. Mix 2 exhibited poor mixing and homogeneity, lower temperature profiles (less than 55°C), low moisture holding capacity, and poor oxygenation characteristics due to its dense composition. Based on the data available, Mix 2 has been deleted from contaminated soil testing.

Mix 3 Mix 3 exhibited good texture, temperature, moisture, and oxygenation characteristics, however, slight segregation of wood chips did occur and the remaining material was very fine. In addition, since the wood chips do not represent a readily available carbon source, the carbon to nitrogen ratio is very low and may inhibit explosives degradation. Mix 3 is similar to Mixes 5 and 6 with the addition of potato waste and sawdust and maintained an average temperature profile near 55°C for nine continuous days and 13 total days. Mix 3 has been selected to be included in the contaminated soil testing.

Mix 4 Mix 4 has the second most undesirable overall rating, however, it exhibited very good texture and homogeneity characteristics and good moisture holding qualities. Mix 4 has also been proven to be effective at explosives degradation in other facilities full scale operations. Mix 4 has been selected to be included in the contaminated soil testing.

Mix 5 Mix 5 has an overall rating at the midpoint of the recipes, exhibited very good texture and homogeneity characteristics, and maintained a temperature profile near 55°C for 17 days. The Mix 5 performance rating is identical to Mix 6, both a variation of a turkey manure recipe. Mix 5 is also a slight variation of Mix 4 with the chicken manure replaced by turkey manure. This may prove to be a key element in the final recipe should the manure type impact explosives degradation. Mix 5 is less costly than Mix 6 and has been selected to be included in the contaminated soil testing.

Mix 6 Similar to Mix 5, Mix 6 exhibited very good texture and homogeneity characteristics and maintained a temperature profile of 55°C for 20 days. Based on slightly higher cost and similar performance to Mix 5, Mix 6 has been deleted from contaminated soil testing.

Mix 7A Mix 7A data was difficult to compare to the pilot scale clean soil test data due to the performance in the early spring months and different monitoring frequencies. Ambient temperatures were as low as 3°C and as high as 19°C with an average over the testing period of 11°C. Temperature, oxygen and moisture measurements at different stages of the compost cycle were reported, however, moisture was presented in percent moisture vs WHC. Mix 7A exhibited very good oxygenation and economic characteristics, however Mix 7A also exhibited the worst temperature profile of the recipes tested. Mix 7A took 9 days to increase to above 40°C and never reached 55°C however, the lower ambient temperatures may have kept the temperature profile at a lower range. Mix 7A's texture and percent moisture at saturation data was not recorded, however, since the recipe is very similar to Mix 7B but with less chicken manure, the texture and moisture ratings

can be assumed to be similar. Based on lowest cost and an estimated rating of the third most desirable, Mix 7A has been selected to be included in the contaminated soil testing.

Mix 7B Mixes 7B and 7C were the highest performers exhibiting very good temperature, texture and homogeneity characteristics. Mix 7B was the more suitable recipe and out performed Mix 7C in the moisture, oxygenation, and economic ratings. Mix 7B has been selected to be included in the contaminated soil testing.

Mix 7C Mix 7C was rated the second most desirable recipe tested. Since Mix 7C is identical to Mix 7B except adjusted for the addition of the vegetable waste, Mix 7C is recommended to be modified and included in the contaminated soil testing as Mix 8. Mix 8 adds 10% cow manure (considered to be a key ingredient in degradation of explosives contaminated soil), has volume adjustments of 3% less chicken manure and 7% less straw, and has the same volume of potato waste and soil as 7C. Mix 8 utilizes the same amendments in different proportions as does Mix 4 except for replacement of the alfalfa and sawdust with straw, an increase in chicken manure to account for the loss of alfalfa nitrogen content and a reduction in cow manure. Mix 8 has been selected to be included in the contaminated soil testing.

TABLE 4-1
SUMMARY OF MIX RATINGS

Category / Mix	Texture	Temp.	Moisture	Oxygenation	Total Rating
2	3	3	3	3	12
3	2	2	2	2	8
4	1	3	2	3	9
5	1	2	2	3	8
6	1	2	2	3	8
7A	1	4	1	1	7
7B	1	1	1	1	4
7C	1	1	2	2	6

Based on agreement between the U.S. Navy and U.S. EPA, the recipes listed in Table 4-2 have been selected for pilot scale testing of contaminated soil.

can be assumed to be similar. Based on lowest cost and an estimated rating of the third most desirable, Mix 7A has been selected to be included in the contaminated soil testing.

Mix 7B Mixes 7B and 7C were the highest performers exhibiting very good temperature, texture and homogeneity characteristics. Mix 7B was the more suitable recipe and out performed Mix 7C in the moisture, oxygenation, and economic ratings. Mix 7B has been selected to be included in the contaminated soil testing.

Mix 7C Mix 7C was rated the second most desirable recipe tested. Since Mix 7C is identical to Mix 7B except adjusted for the addition of the vegetable waste, Mix 7C is recommended to be modified and included in the contaminated soil testing as Mix 8. Mix 8 adds 10% cow manure (considered to be a key ingredient in degradation of explosives contaminated soil), has volume adjustments of 3% less chicken manure and 7% less straw, and has the same volume of potato waste and soil as 7C. Mix 8 utilizes the same amendments in different proportions as does Mix 4 except for replacement of the alfalfa and sawdust with straw, an increase in chicken manure to account for the loss of alfalfa nitrogen content and a reduction in cow manure. Mix 8 has been selected to be included in the contaminated soil testing.

TABLE 4-1
SUMMARY OF MIX RATINGS

Category / Mix	Texture	Temp.	Moisture	Oxygenation	Total Rating
2	3	3	3	3	12
3	2	2	2	2	8
4	1	3	2	3	9
5	1	2	2	3	8
6	1	2	2	3	8
7A	1	4	1	1	7
7B	1	1	1	1	4
7C	1	1	2	2	6

Based on agreement between the U.S. Navy and U.S. EPA, the recipes listed in Table 4-2 have been selected for pilot scale testing of contaminated soil.

TABLE 4-2 RECOMMENDED PILOT SCALE CONTAMINATED SOIL WINDROW RECIPES							
Amendment (in percent)	Mix						
	1	3	4	5	7A	7B	8
POTW Sludge	25.00						
Alfalfa	25.00	25.00	19.25	19.25			
Sawdust	12.50		19.25	19.25			
Wood Chips	12.50	25.00					
Soil	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Turkey Manure		25.00		25.75			
Chicken Manure			3.25		3.50	15.00	7.00
Cow Manure			22.50				10.00
Vegatable Waste			10.75	10.75			10.00
Straw					71.50	60.00	48.00
Total	100	100	100	100	100	100	100

5.0
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APPENDIX A
"DRY RUN" REPORT

NSWC CRANE
BIOFACILITY
SUMMARY REPORT
DRY RUN

On February 26, 1997 Morrison Knudsen (MK) began the Dry Run operation with Mixes 3 and 4. Mix 3 consisted of cow manure, corn stalks, and clean soil. Mix 4 consisted of chicken manure, corn stalks, and clean soil. The moisture content of these two mixes were kept as close as possible to the 40% that is common in composting literature. However with the addition of the soil to the mixes this moisture content caused Mixes 3 and 4 to become saturated reducing the pore space and not allowing the mixes to heat up. On March 3, 1997 Mixes 3 and 4 were removed from the biofacility.

On February 28, 1997 Mix 6, containing straw, alfalfa, cow manure, and clean soil, was started. This mix responded well in initial heating. The mix was turned one or more times daily to maintain pore space. Water in the amount of 150-200 gallons was added to the mix of March 5, 6, and 7. The average temperature for the mix remained greater than 100 F until March 7 then it began to slowly cool until the mix was disposed of on March 10 at which time the temperature was 80 F.

On March 4, 1997 Mix 8, containing chicken manure, corn stalks, alfalfa, cow manure, wood chips, and clean soil, was started. This mix began with temperatures in the 50-60 F range and climbed to the mid 80's during the middle of the test before dropping back to the 70's during the last two days of the test. Moisture in the amount of 150 to 200 gallons of water was added to the mix on March 6 and 7. The mix was disposed of on March 10.

On March 9, 1997 Mix 1, containing straw, cow manure, and clean soil, was started. The mix had good initial heating. Water was added to the mix on four consecutive days after the first day and then again on day seven. During this period the average temperature of the mix began to fall and it appeared to be much more dense. We did not add water for the remainder of the mix life and the temperatures began to recover and hold in the 70's and 80's. The appearance of the mix began to loosen and look more like the other piles. Also, during the last five days of the run we did not turn the pile to see if the heating would continue. We found that the heat remained relatively constant but the pile began to settle reducing the pore space.

On March 14, 1997 Mix 2, containing straw, chicken manure, and clean soil, was started. Water was added on days 5,6, and 13. The temperature average for this mix remained in the 100's since day 9. During the last five days of the run when we did not turn the piles the mix maintained good heat and did not compact dramatically.

On March 18, 1997 Mix 7, containing straw, alfalfa, cow manure, wood chips, and clean soil, was started. Water was added on day 1,3, 5, 6, 13, and 16. The mix had good initial heating and during the middle of the run temperatures were in the 100's. During the five day period at the end of the run when the piles were not turned the temperatures fell into the 80's and the pile became more dense.

On March 21, 1997 Mix 5, containing straw, chicken manure, cow manure, and clean soil, was started. Water was added on days 1, 3, 4, 11, and 15. Beginning on day 3 the mix temperature remained above 110 F until day 11 after which the temperature began to slowly fall. The temperatures were already down to the low 70's when we began not turning the piles. The pile maintained the low 70's temperatures until the end of the run.

Attached to this summary are the following graphs and tables:

DRY RUN MIX RECIPES
DRY RUN PRE-TURN TEMPERATURES
DRY RUN C:N RATIOS
DRY TEMPERATURE AND MOISTURE
DRY RUN OXYGEN AND pH

NSWC CRANE
DRY RUN MIX RECIPES

(Mix #4)		Date 2/25/97	Time 1900
Ingredient	Estimated Qty. (CY)	Estimated Qty. (lbs.)	Actual Qty. (lbs.)
Straw		0	0
Chicken Manure	1	1450	4590
Corn Stalks	49	9800	9550
Alfalfa		0	0
Cow Manure		0	0
Wood Chips		0	0
Amendment Totals	50	11250	14140
Soil	16.6	50000	48900
Batch Total	66.6	61250	63040

(Mix #3)		Date 2/26/97	Time 1130
Ingredient	Estimated Qty. (CY)	Estimated Qty. (lbs.)	Actual Qty. (lbs.)
Straw		0	0
Chicken Manure		0	0
Corn Stalks	38	7600	7640
Alfalfa		0	0
Cow Manure	12	17100	17100
Wood Chips		0	0
Amendment Totals	50	24700	24740
Soil	16.6	50000	50000
Batch Total	66.6	74700	74740

(Mix #6)		Date 2/27/97	Time 1800
Ingredient	Estimated Qty. (CY)	Estimated Qty. (lbs.)	Actual Qty. (lbs.)
Straw	13	2600	2460
Chicken Manure		0	0
Corn Stalks		0	0
Alfalfa	24	9600	9400
Cow Manure	13	18525	19700
Wood Chips		0	0
Amendment Totals	50	30725	31560
Soil	16.6	50000	50000
Batch Total	66.6	80725	81560

NSWC CRANE
DRY RUN MIX RECIPES

(Mix #8)		Date 3/4/97	Time 1500
Ingredient	Estimated Qty. (CY)	Estimated Qty. (lbs.)	Actual Qty. (lbs.)
Straw		0	0
Chicken Manure	2.5	3625	4430
Corn Stalks	7.5	1500	1770
Alfalfa	12	4800	4970
Cow Manure	15	21375	23040
Wood Chips	13	6890	7020
Amendment Totals	50	38190	41230
Soil	16.6	50000	49800
Batch Total	66.6	88190	90130

(Mix #1)		Date 3/9/97	Time 0900
Ingredient	Estimated Qty. (CY)	Estimated Qty. (lbs.)	Actual Qty. (lbs.)
Straw	37	7400	7600
Chicken Manure			
Corn Stalks			
Alfalfa			
Cow Manure	13	18525	18425
Wood Chips			
Amendment Totals	50	25925	26025
Soil	16.6	50000	50000
Batch Total	66.6	75925	76025

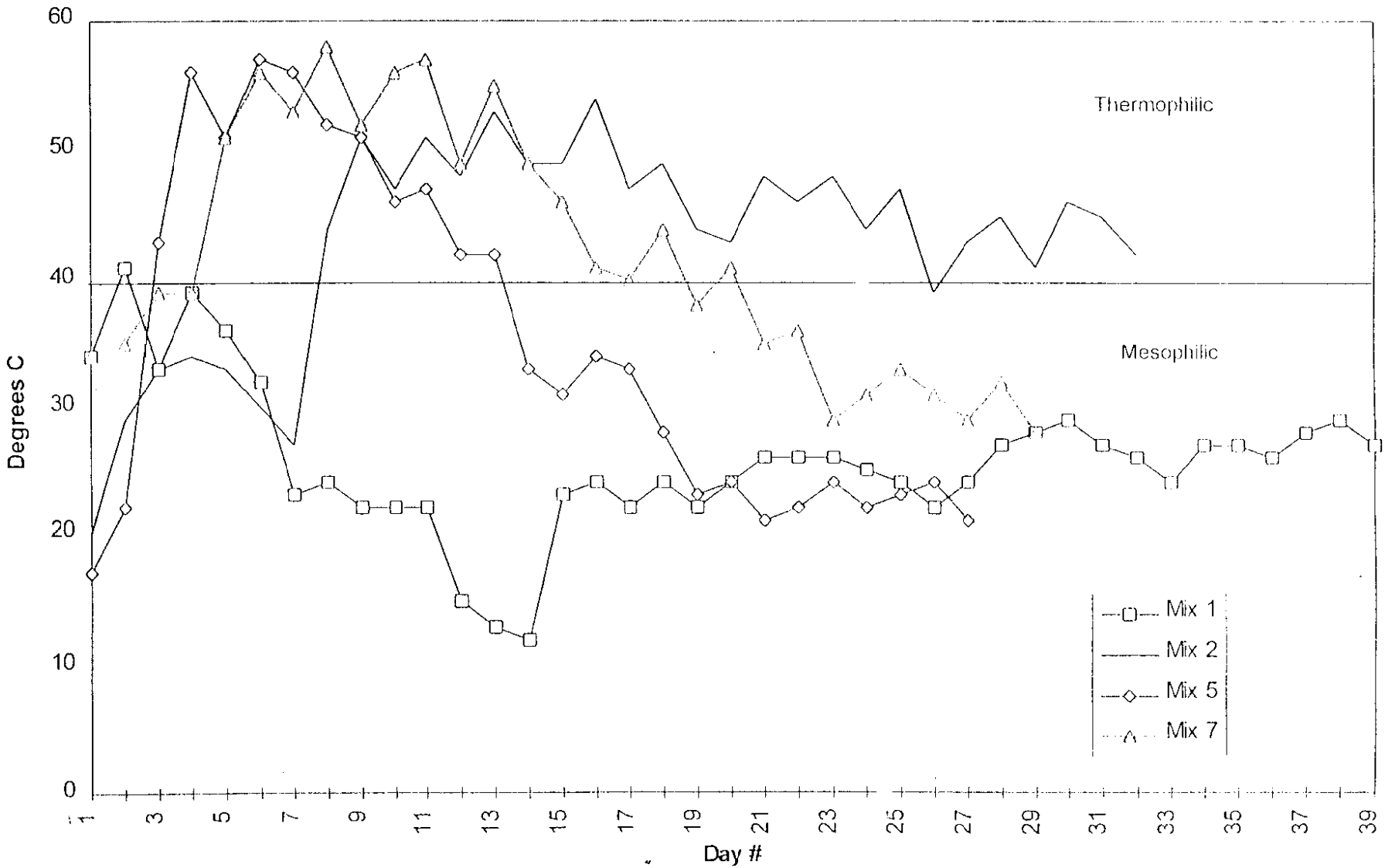
(Mix #2)		Date 3/14/97	Time 1630
Ingredient	Estimated Qty. (CY)	Estimated Qty. (lbs.)	Actual Qty. (lbs.)
Straw	48	9600	10330
Chicken Manure	2	2900	3310
Corn Stalks			
Alfalfa			
Cow Manure			
Wood Chips			
Amendment Totals	50	12500	13640
Soil	16.6	44820	42400
Batch Total	66.6	57320	56040

NSWC CRANE
DRY RUN MIX RECIPES

(Mix #5)		Date 3/19/97	Time 1730
Ingredient	Estimated Qty. (CY)	Estimated Qty. (lbs.)	Actual Qty. (lbs.)
Straw	46.5	9300	9820
Chicken Manure	0.5	725	870
Corn Stalks			
Alfalfa			
Cow Manure	3	4275	4250
Wood Chips			
Amendment Totals	50	14300	14940
Soil	16.6	44820	42400
Batch Total	66.6	59120	57340

(Mix #7)		Date 3/17/97	Time 1730
Ingredient	Estimated Qty. (CY)	Estimated Qty. (lbs.)	Actual Qty. (lbs.)
Straw	32	6400	6700
Chicken Manure			
Corn Stalks			
Alfalfa	5	2000	2150
Cow Manure	8	11400	11380
Wood Chips	5	2650	2660
Amendment Totals	50	22450	20230
Soil	16.6	44820	42400
Batch Total	66.6	67270	62630

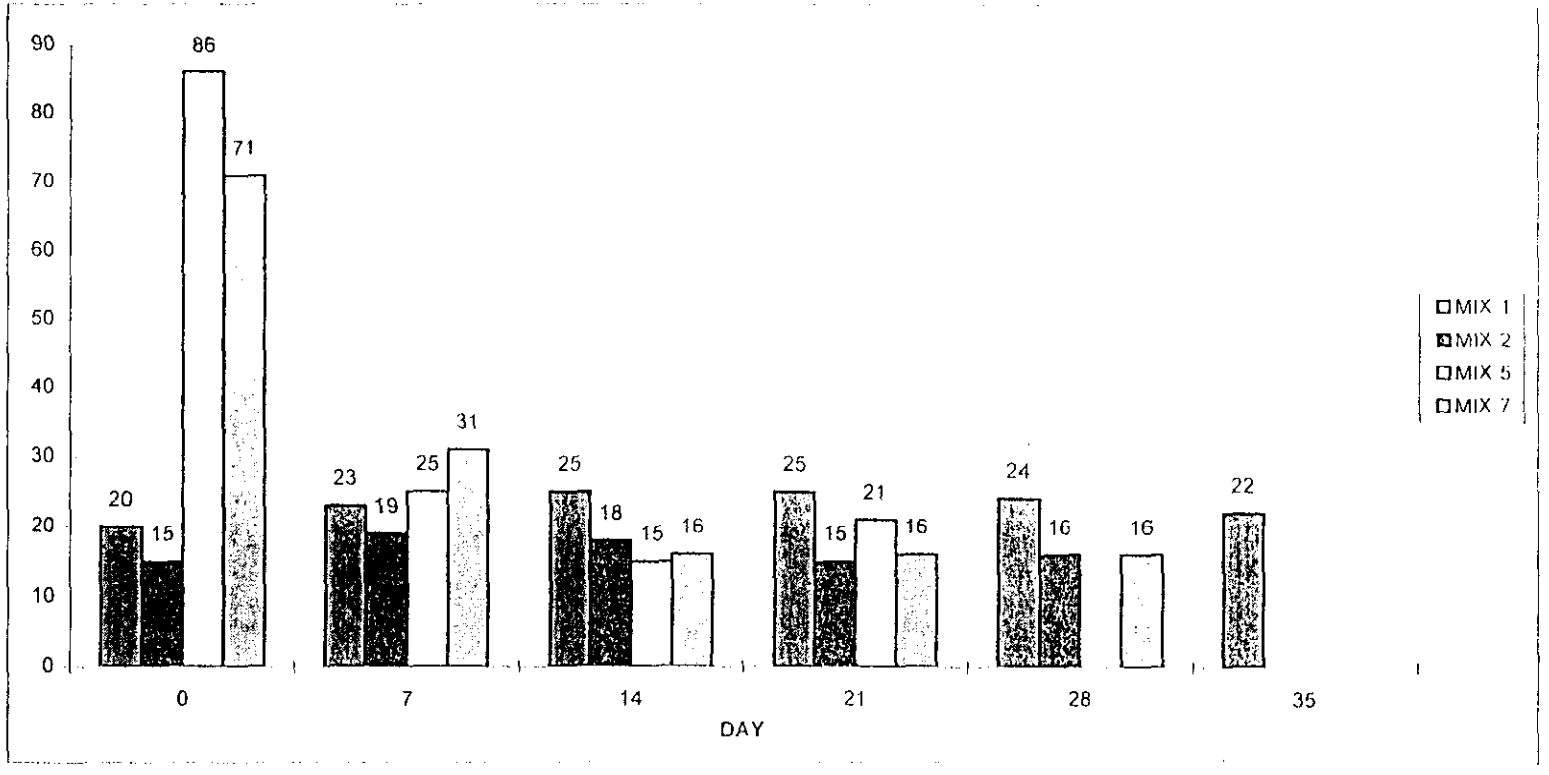
NSWC CRANE
DRY RUN PRE-TURN TEMPERATURES
Degrees C



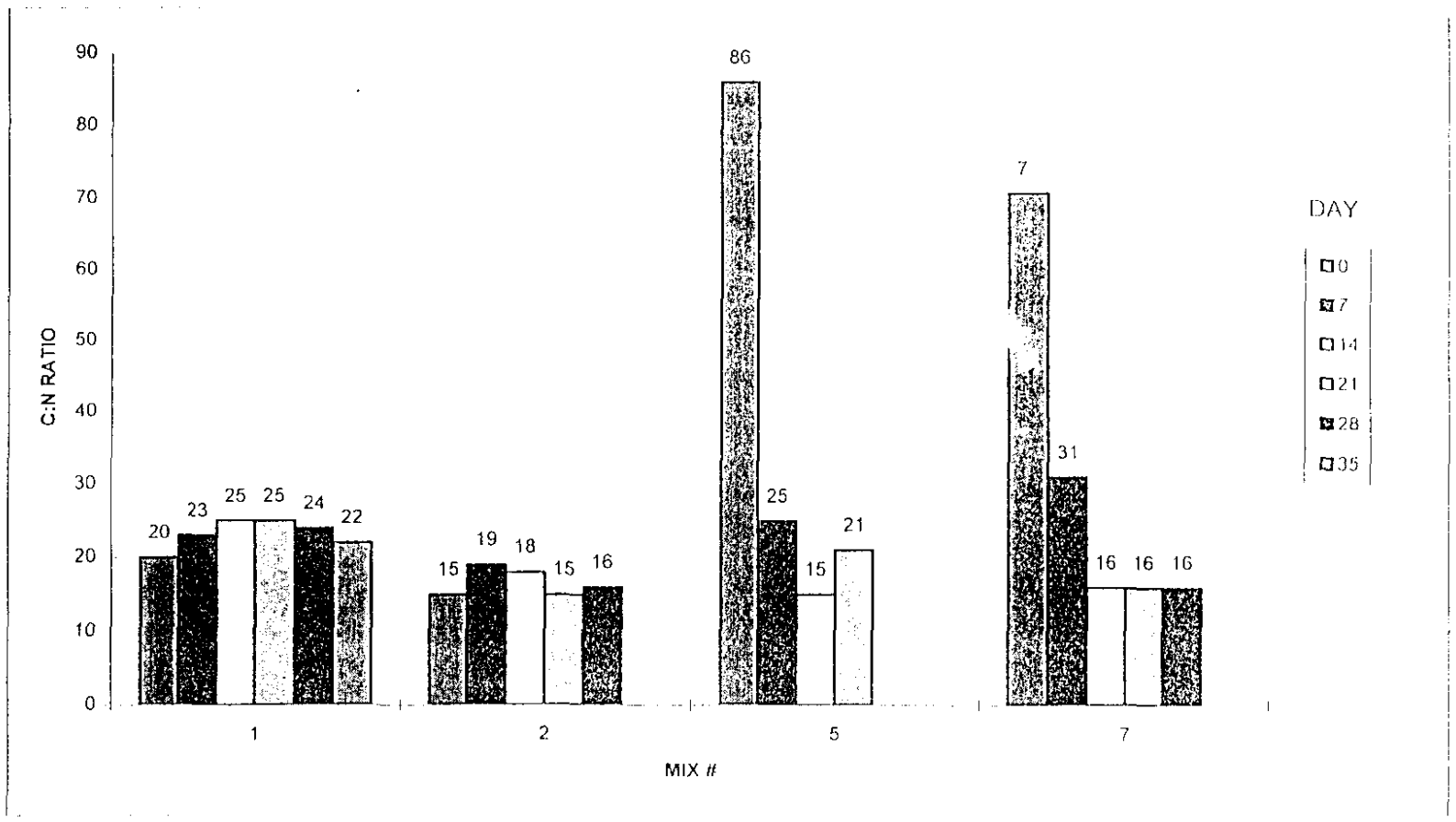
NSWC CR

DRY RUN C:N RATIOS

DAY	MIX 1	2	5	7
0	20	15	86	71
7	23	19	25	31
14	25	18	15	16
21	25	15	21	16
28	24	16		16
35	22			



NSWC CRANE
DRY RUN C:N RATIOS



NSWC CRANE
DRY RUN C:N RATIOS
MIX 1

DAY 1

CRA/BDR 101 3/10/97 COC 2

Cross Section	Sample Location 1	2	3	Avg.
A	28	21	28	26
B	19	7	41	22
C	19	7	11	12
D	18	20	21	20
Avg.	21	14	25	**20**

DAY 7

CRA/BDR 107 3/16/97 COC 4

Cross Section	Sample Location 1	2	3	Avg.
A	27	27	21	25
B	25	19	14	19
C	30	23	19	24
D	26	27	13	22
Avg.	27	24	17	**23**

DAY 14

CRA/BDR 114 3/23/97 COC 8

Cross Section	Sample Location 1	2	3	Avg.
A	23	30	24	26
B	24	25	26	25
C	28	24	23	25
D	26	25	27	26
Avg.	25	26	25	**25**

DAY 21

CRA/BDR 121 3/30/97 COC 12

Cross Section	Sample Location 1	2	3	Avg.
A	23	19	23	22
B	27	24	22	24
C	25	32	25	27
D	25	28	28	27
Avg.	25	26	25	**25**

CRA = Crane
BDR ### = Biofacility Dry Run, Mix #, Day ##
Date Sampled
COC = Chain of Custody #

NSWC CRANE
DRY RUN C:N RATIOS
MIX 1

DAY 28

CRA/BDR 128 4/6/97 COC 16

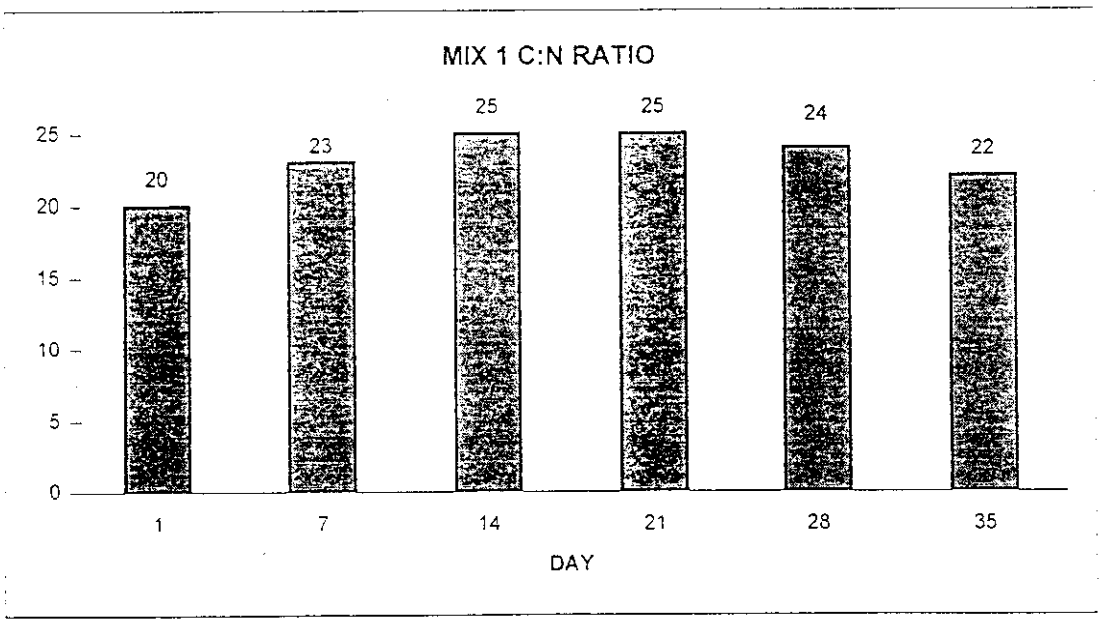
Cross Section	Sample Location 1	2	3	Avg.
A	23	23	23	23
B	22	23	24	23
C	27	24	25	25
D	24	22	22	23
Avg.	24	23	24	**24**

DAY 35

CRA/BDR 135 4/13/97 COC 20

Cross Section	Sample Location 1	2	3	Avg.
A	21	21	21	21
B	19	21	22	21
C	22	25	27	25
D	22	20	21	21
Avg.	21	22	23	**22**

DAY	AVG. RATIO
1	20
7	23
14	25
21	25
28	24
35	22



CRA = Crane
BDR ### = Biofacility Dry Run, Mix #, Day ##
Date Sampled
COC = Chain of Custody #

NSWC CRANE
DRY RUN C:N RATIOS
MIX 2

DAY 0

CRA/BDR 200 3/15/97 COC 3

Cross Section	Sample Location 1	2	3	Avg.
A	11	7	5	8
B	9	3	3	5
C	7	23	34	21
D	30	25	17	24
Avg.	14	15	15	15

DAY 7

CRA/BDR 207 3/22/97 COC 7

Cross Section	Sample Location 1	2	3	Avg.
A	17	18	26	20
B	18	15	25	19
C	14	9	20	14
D	22	19	26	22
Avg.	18	15	24	19

DAY 14

CRA/BDR 214 3/29/97 COC 11

Cross Section	Sample Location 1	2	3	Avg.
A	23	15	13	17
B	21	15	20	19
C	13	20	16	16
D	19	21	20	20
Avg.	19	18	17	18

DAY 21

CRA/BDR 221 4/5/97 COC 15

Cross Section	Sample Location 1	2	3	Avg.
A	13	15	14	14
B	16	13	15	15
C	15	16	14	15
D	20	14	16	17
Avg.	16	15	15	15

CRA = Crane
BDR ### = Biofacility Dry Run, Mix #, Day ##
Date Sampled
COC = Chain of Custody #

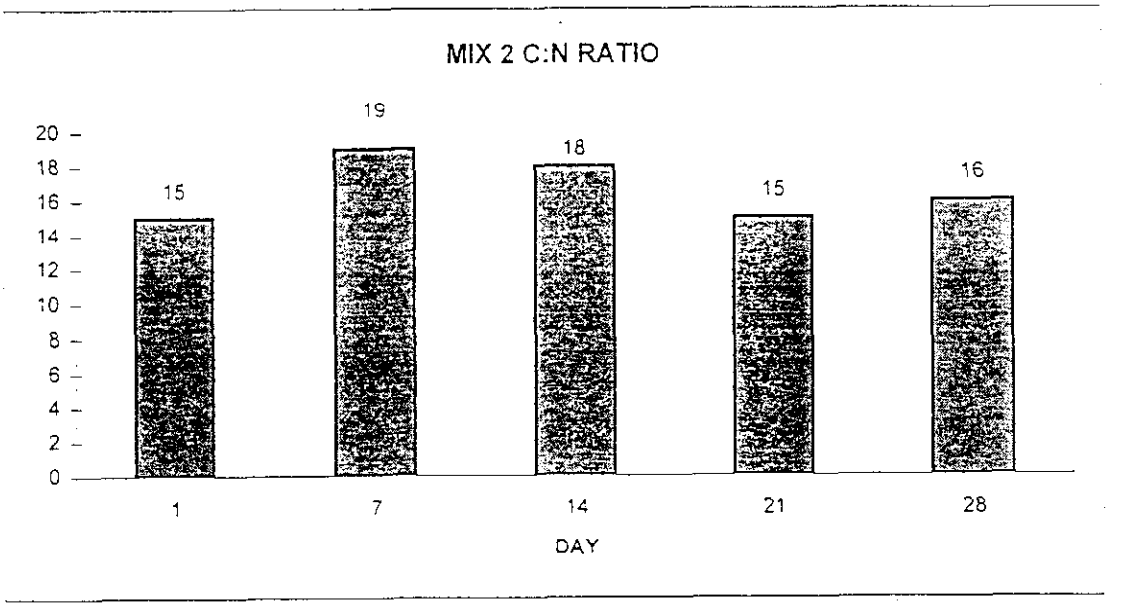
NSWC CRANE
DRY RUN C:N RATIOS
MIX 2

DAY 28

CRA/BDR 228 4/12/97 COC 19

Cross Section	Sample Location 1	2	3	Avg.
A	19	15	18	17
B	14	13	15	14
C	18	22	20	20
D	12	11	13	12
Avg.	16	15	17	**16**

DAY	RATIO
1	15
7	19
14	18
21	15
28	16



CRA = Crane
BDR ### = Biofacility Dry Run, Mix #, Day ##
Date Sampled
COC = Chain of Custody #

NSWC CRANE
DRY RUN C:N RATIOS
MIX 5

DAY 0

CRA/BDR 500 3/21/97 COC 6

Cross Section	Sample Location 1	2	3	Avg.
A	158	48	8	71
B	157	113	38	103
C	174	154	122	150
D	8	31	20	20
Avg.	124	87	47	**86**

DAY 7

CRA/BDR 507 3/28/97 COC 10

Cross Section	Sample Location 1	2	3	Avg.
A	7	70	18	32
B	19	33	29	27
C	24	22	16	21
D	21	19	25	22
Avg.	18	36	22	**25**

DAY 14

CRA/BDR 514 4/4/97 COC 14

Cross Section	Sample Location 1	2	3	Avg.
A	11	16	15	14
B	19	15	16	17
C	15	15	16	15
D	10	19	16	15
Avg.	14	16	16	**15**

DAY 21

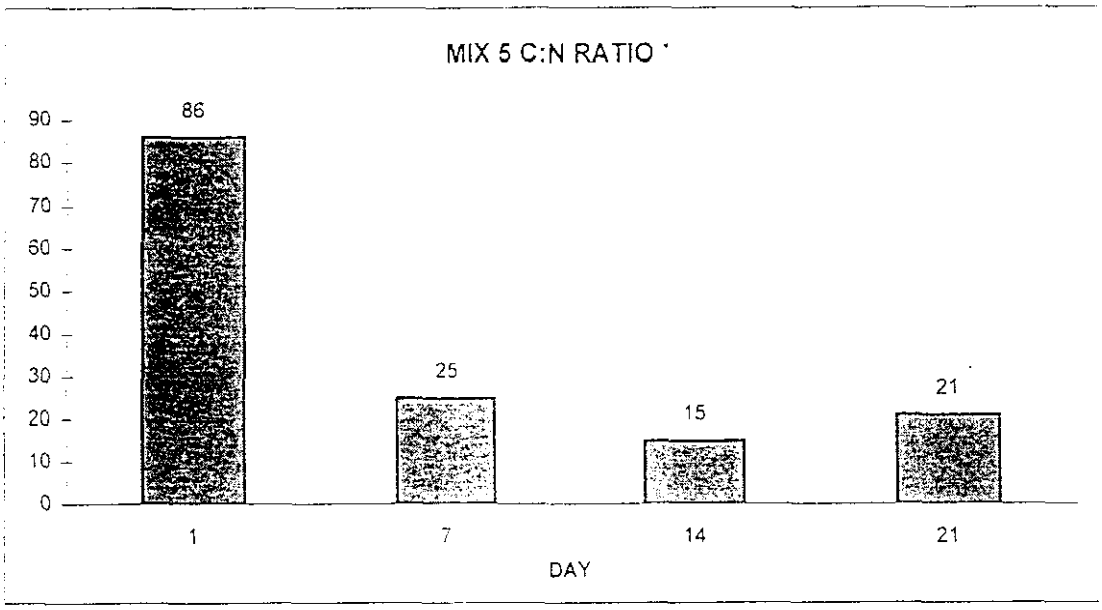
CRA/BDR 521 4/11/97 COC 18

Cross Section	Sample Location 1	2	3	Avg.
A	20	18	14	17
B	16	14	17	16
C	12	21	20	18
D	23	63	17	34
Avg.	18	29	17	**21**

CRA = Crane
BDR ### = Biofacility Dry Run, Mix #, Day ##
Date Sampled
COC = Chain of Custody #

NSWC CRANE
DRY RUN C:N RATIOS
MIX 5

DAY	RATIO
1	86
7	25
14	15
21	21



CRA = Crane
BDR ### = Biofacility Dry Run, Mix #, Day ##
Date Sampled
COC = Chain of Custody #

NSWC CRANE
DRY RUN C:N RATIOS
MIX 7

DAY 0

CRA/BDR 700 3/18/97 COC 5

Cross Section	Sample Location 1	2	3	Avg.
A	12	71	46	43
B	10	35	128	58
C	29		412	147
D	10	70	27	36
Avg.	15	44	153	71

DAY 7

CRA/BDR 707 3/25/97 COC 9

Cross Section	Sample Location 1	2	3	Avg.
A		184	22	69
B	22	17	14	1[illegible]
C	19	20	19	19
D	20	8	27	18
Avg.	15	57	21	31

DAY 14

CRA/BDR 714 4/1/97 COC 13

Cross Section	Sample Location 1	2	3	Avg.
A	12	21	17	17
B	18	15	15	16
C	20	8	17	15
D	17	15	13	15
Avg.	17	15	16	16

DAY 22

CRA/BDR 722 4/9/97 COC 17

Cross Section	Sample Location 1	2	3	Avg.
A	17	17	15	16
B	20	18	15	18
C	13	15	19	16
D	13	16	12	14
Avg.	16	17	15	16

CRA = Crane
BDR ### = Biofacility Dry Run, Mix #, Day ##
Date Sampled
COC = Chain of Custody #

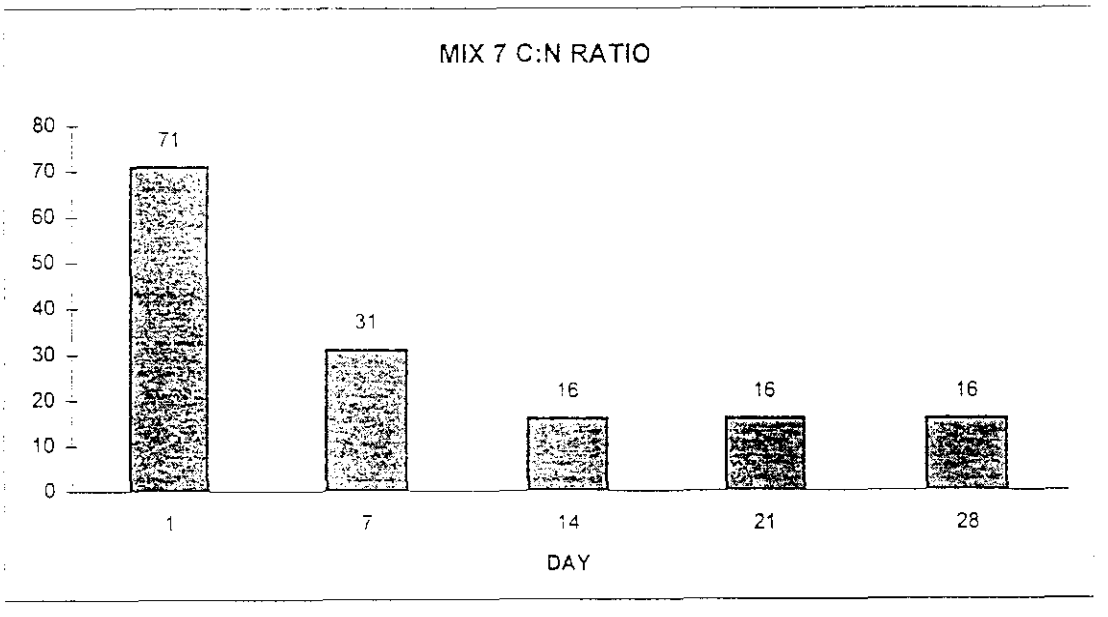
NSWC CRANE
DRY RUN C:N RATIOS
MIX 7

DAY 28

CRA/BDR 728 4/15/97 COC 21

Cross Section	Sample Location 1	2	3	Avg.
A	21	19	12	17
B	28	15	14	19
C	12	14	15	14
D	12	14	16	14
Avg.	18	16	14	16

DAY	RATIO
1	71
7	31
14	16
21	16
28	16



CRA = Crane
BDR ### = Biofacility Dry Run, Mix #, Day ##
Date Sampled
COC = Chain of Custody #

NSWC CRANE
DRY RUN MIX RECIPES

(Mix #4)		Date 2/25/97	Time 1900
Ingredient	Estimated Qty. (CY)	Estimated Qty. (lbs.)	Actual Qty. (lbs.)
Straw		0	0
Chicken Manure	1	1450	4590
Corn Stalks	49	9800	9550
Alfalfa		0	0
Cow Manure		0	0
Wood Chips		0	0
Amendment Totals	50	11250	14140
Soil	16.6	50000	48900
Batch Total	66.6	61250	63040

(Mix #3)		Date 2/26/97	Time 1130
Ingredient	Estimated Qty. (CY)	Estimated Qty. (lbs.)	Actual Qty. (lbs.)
Straw		0	0
Chicken Manure		0	0
Corn Stalks	38	7600	7640
Alfalfa		0	0
Cow Manure	12	17100	17100
Wood Chips		0	0
Amendment Totals	50	24700	24740
Soil	16.6	50000	50000
Batch Total	66.6	74700	74740

(Mix #6)		Date 2/27/97	Time 1800
Ingredient	Estimated Qty. (CY)	Estimated Qty. (lbs.)	Actual Qty. (lbs.)
Straw	13	2600	2460
Chicken Manure		0	0
Corn Stalks		0	0
Alfalfa	24	9600	9400
Cow Manure	13	18525	19700
Wood Chips		0	0
Amendment Totals	50	30725	31560
Soil	16.6	50000	50000
Batch Total	66.6	80725	81560

NSWC CRANE
DRY RUN MIX RECIPES

(Mix #8)		Date 3/4/97	Time 1500
Ingredient	Estimated Qty. (CY)	Estimated Qty. (lbs.)	Actual Qty. (lbs.)
Straw		0	0
Chicken Manure	2.5	3625	4430
Corn Stalks	7.5	1500	1770
Alfalfa	12	4800	4970
Cow Manure	15	21375	23040
Wood Chips	13	6890	7020
Amendment Totals	50	38190	41230
Soil	16.6	50000	49800
Batch Total	66.6	88190	90130

(Mix #1)		Date 3/9/97	Time 0900
Ingredient	Estimated Qty. (CY)	Estimated Qty. (lbs.)	Actual Qty. (lbs.)
Straw	37	7400	7600
Chicken Manure			
Corn Stalks			
Alfalfa			
Cow Manure	13	18525	18425
Wood Chips			
Amendment Totals	50	25925	26025
Soil	16.6	50000	50000
Batch Total	66.6	75925	76025

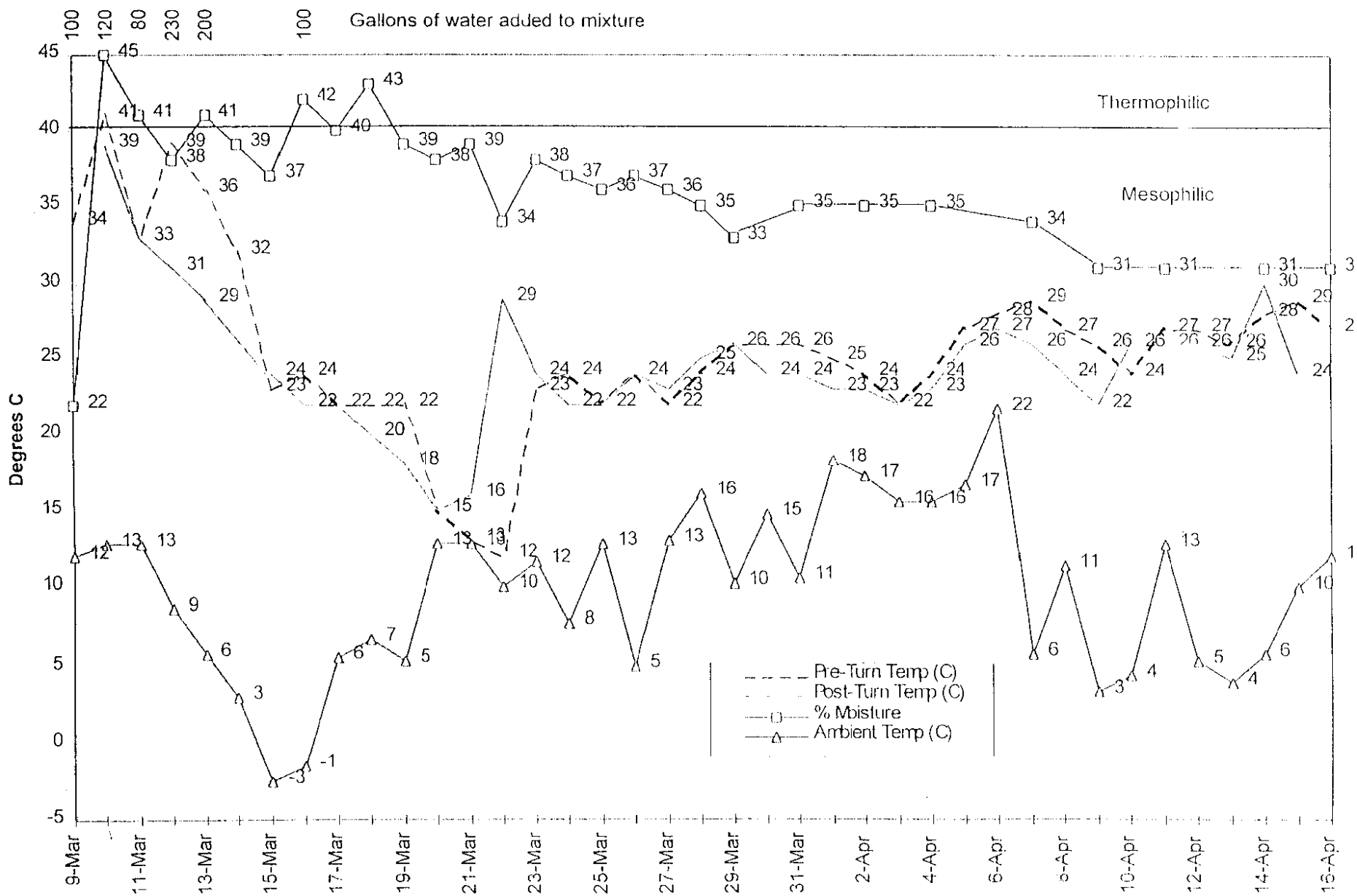
(Mix #2)		Date 3/14/97	Time 1630
Ingredient	Estimated Qty. (CY)	Estimated Qty. (lbs.)	Actual Qty. (lbs.)
Straw	48	9600	10330
Chicken Manure	2	2900	3310
Corn Stalks			
Alfalfa			
Cow Manure			
Wood Chips			
Amendment Totals	50	12500	13640
Soil	16.6	44820	42400
Batch Total	66.6	57320	56040

NSWC CRANE
DRY RUN MIX RECIPES

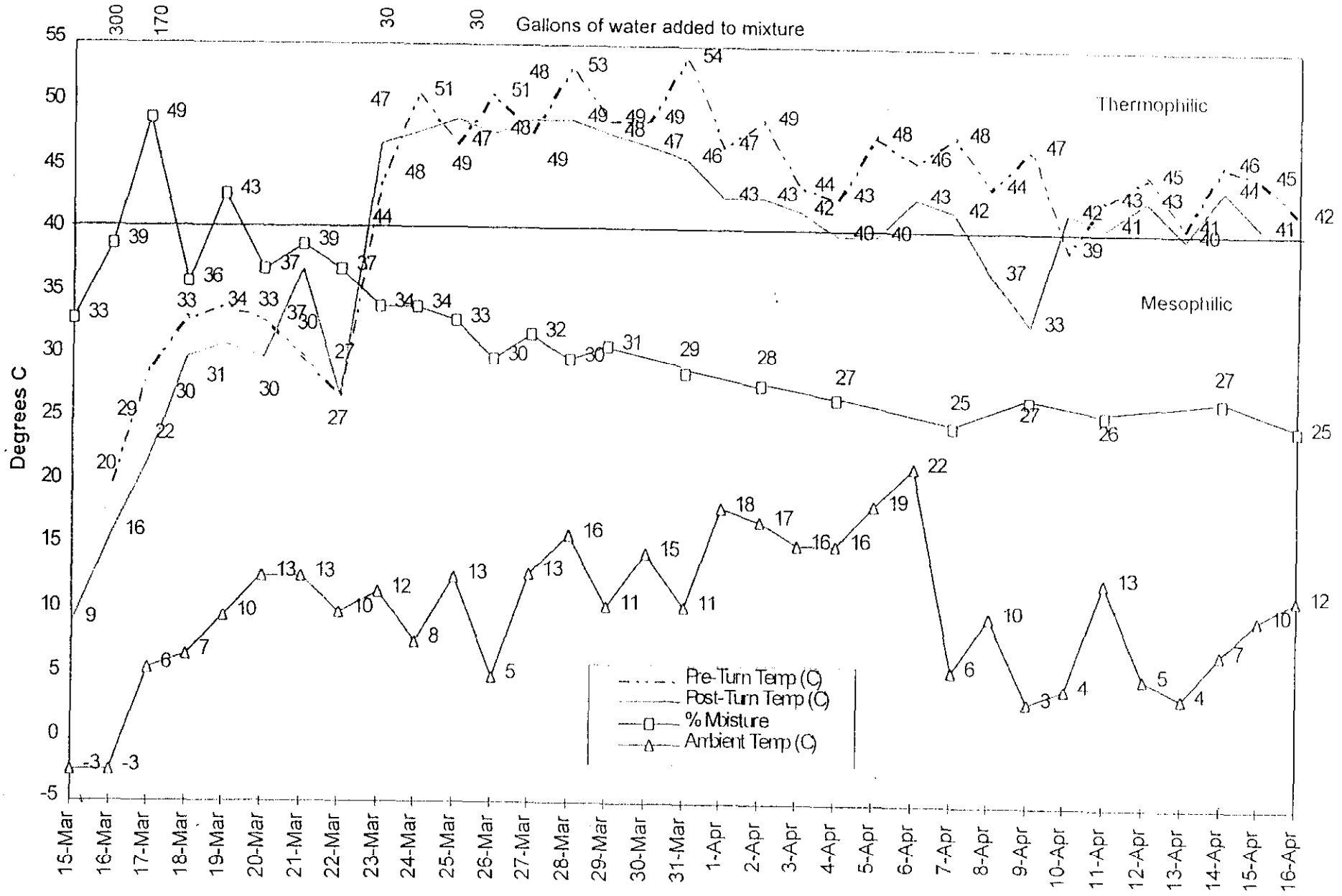
(Mix #5)		Date 3/19/97	Time 1730
Ingredient	Estimated Qty. (CY)	Estimated Qty. (lbs.)	Actual Qty. (lbs.)
Straw	46.5	9300	9820
Chicken Manure	0.5	725	870
Corn Stalks			
Alfalfa			
Cow Manure	3	4275	4250
Wood Chips			
Amendment Totals	50	14300	14940
Soil	16.6	44820	42400
Batch Total	66.6	59120	57340

(Mix #7)		Date 3/17/97	Time 1730
Ingredient	Estimated Qty. (CY)	Estimated Qty. (lbs.)	Actual Qty. (lbs.)
Straw	32	6400	6700
Chicken Manure			
Corn Stalks			
Alfalfa	5	2000	2150
Cow Manure	8	11400	11380
Wood Chips	5	2650	2660
Amendment Totals	50	22450	20230
Soil	16.6	44820	42400
Batch Total	66.6	67270	62630

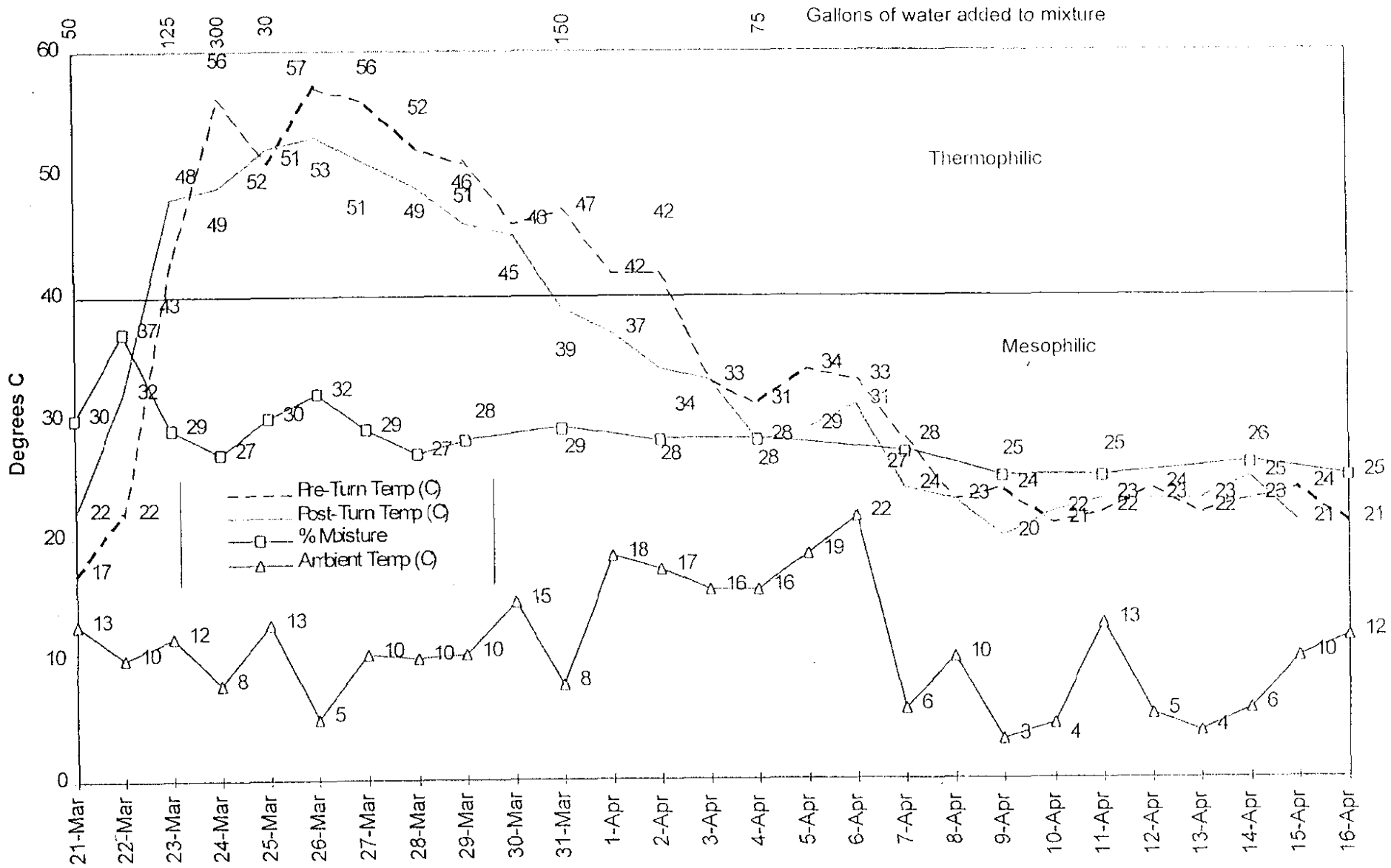
NSWC CRANE
DRY RUN MIX 1 TEMPERATURE PROFILE



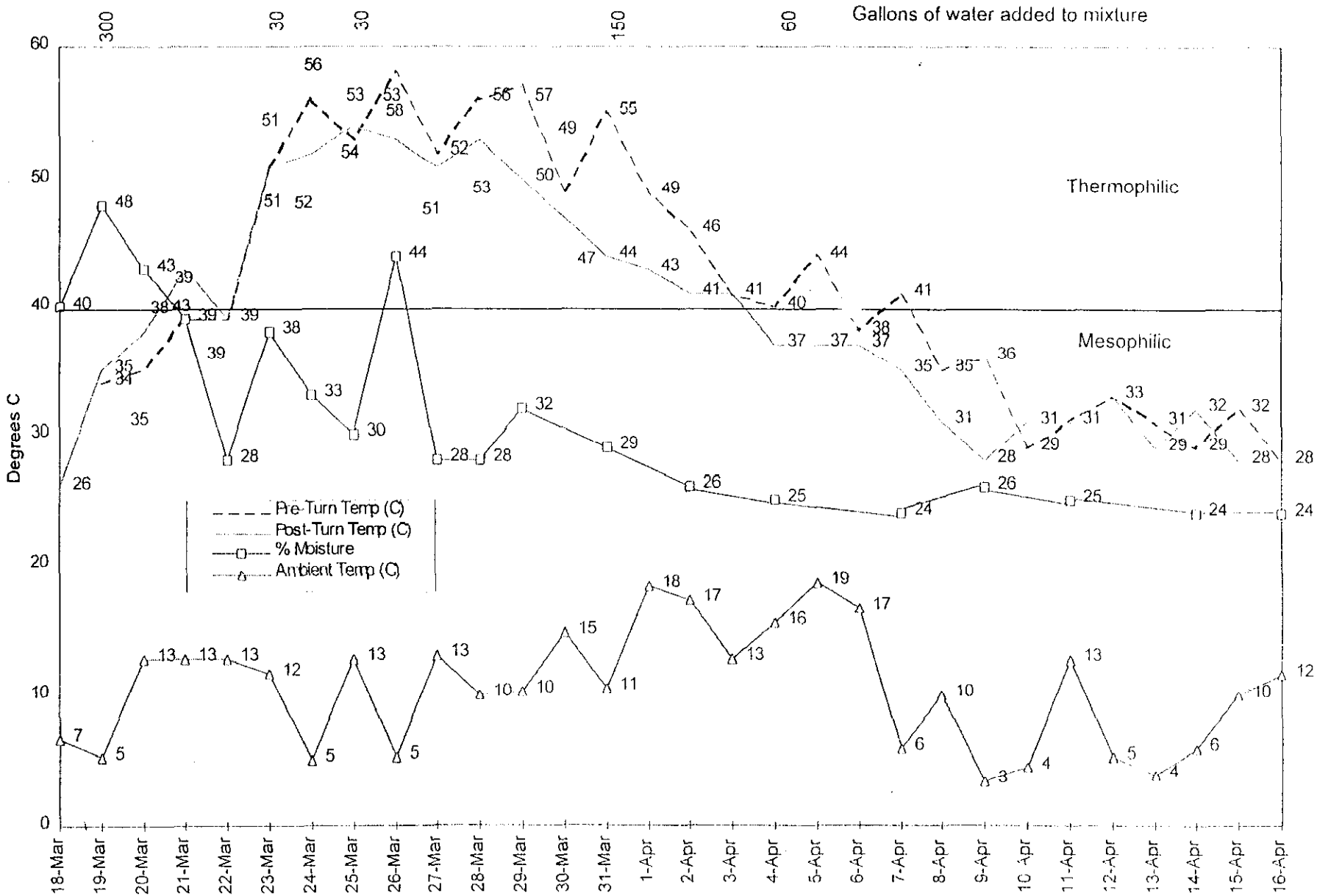
NSWC CRANE
DRY RUN MIX 2 TEMPERATURE PROFILE



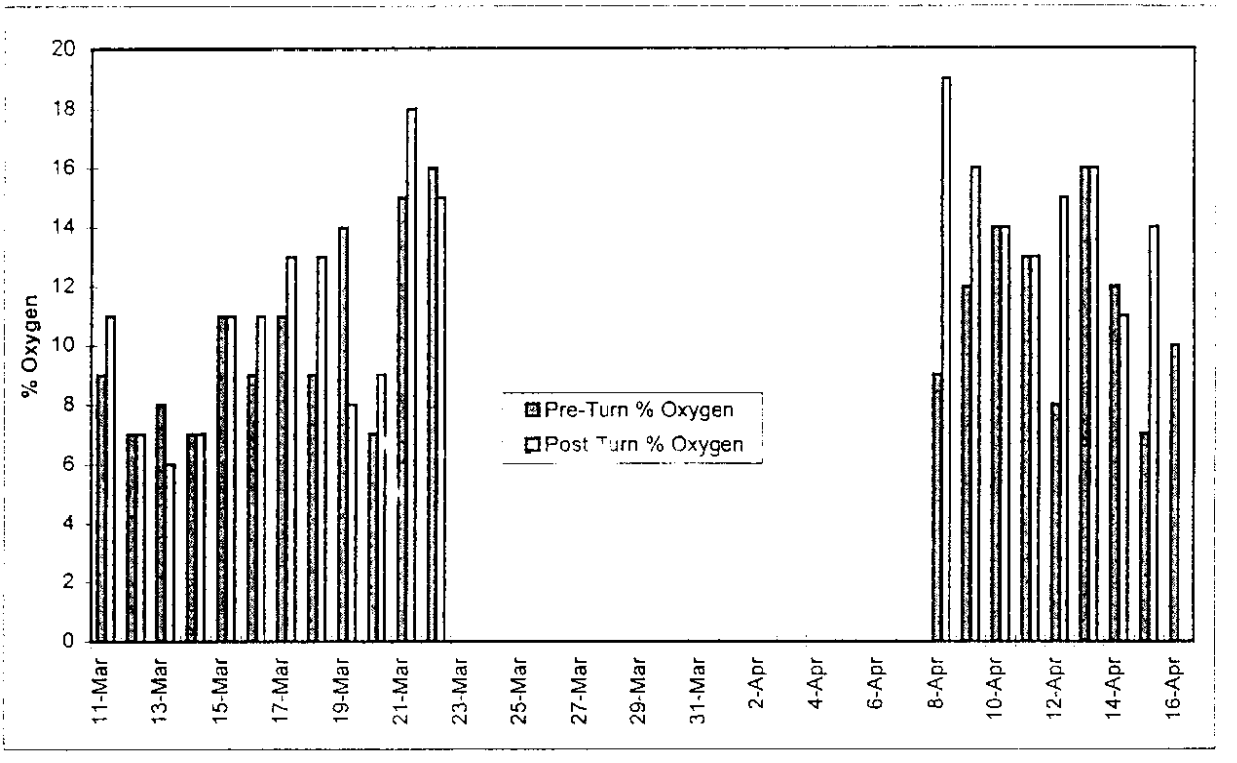
NSWC CRANE
DRY RUN MIX 5 TEMPERATURE PROFILE

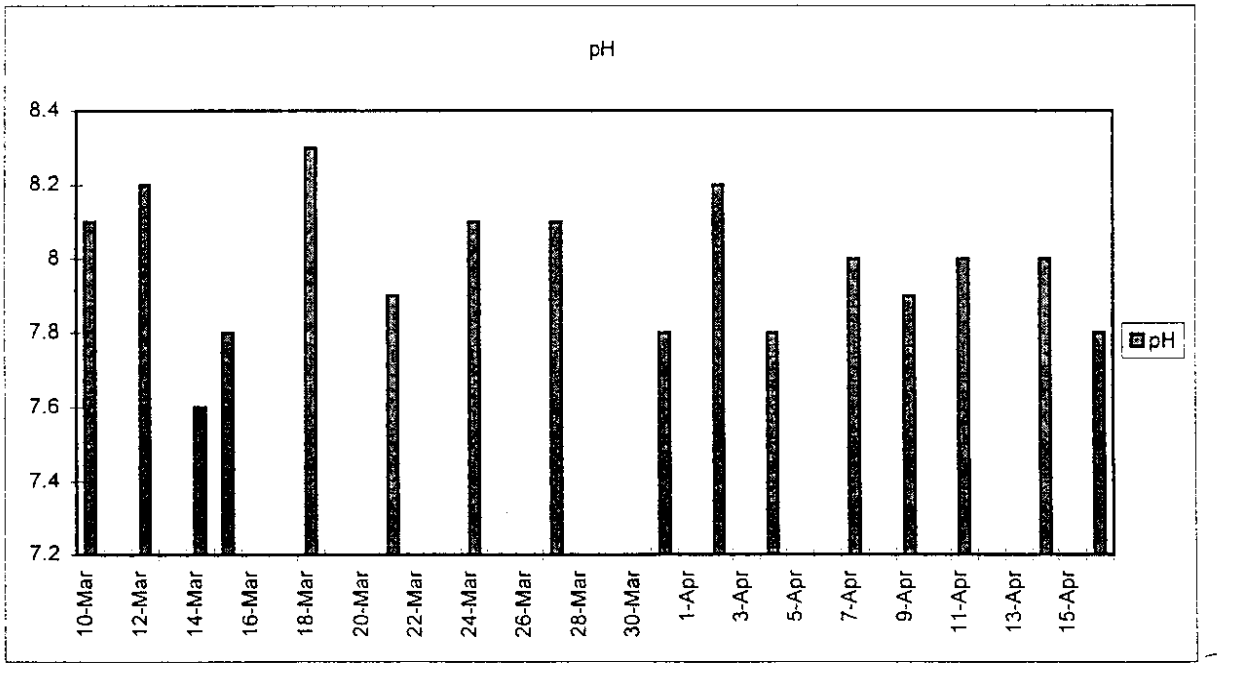


NSWC CRANE
DRY RUN MIX 7 TEMPERATURE PROFILE

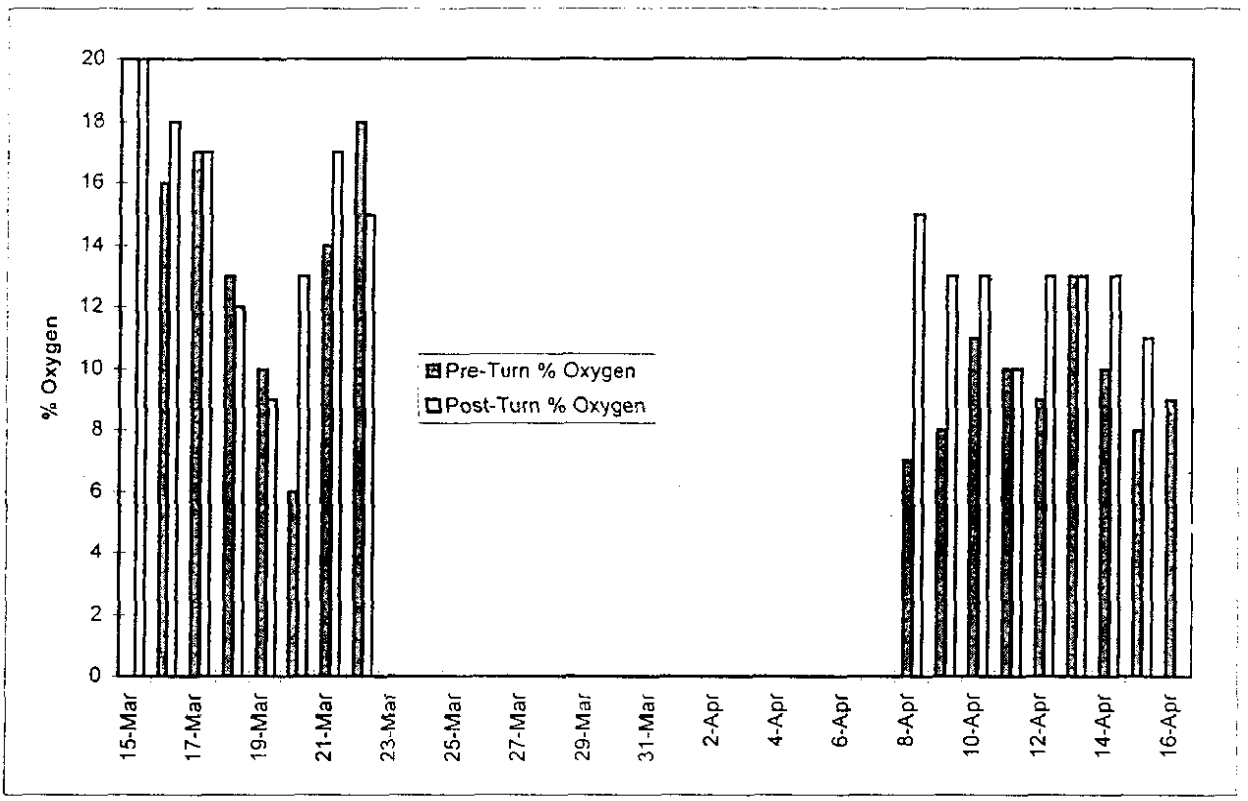


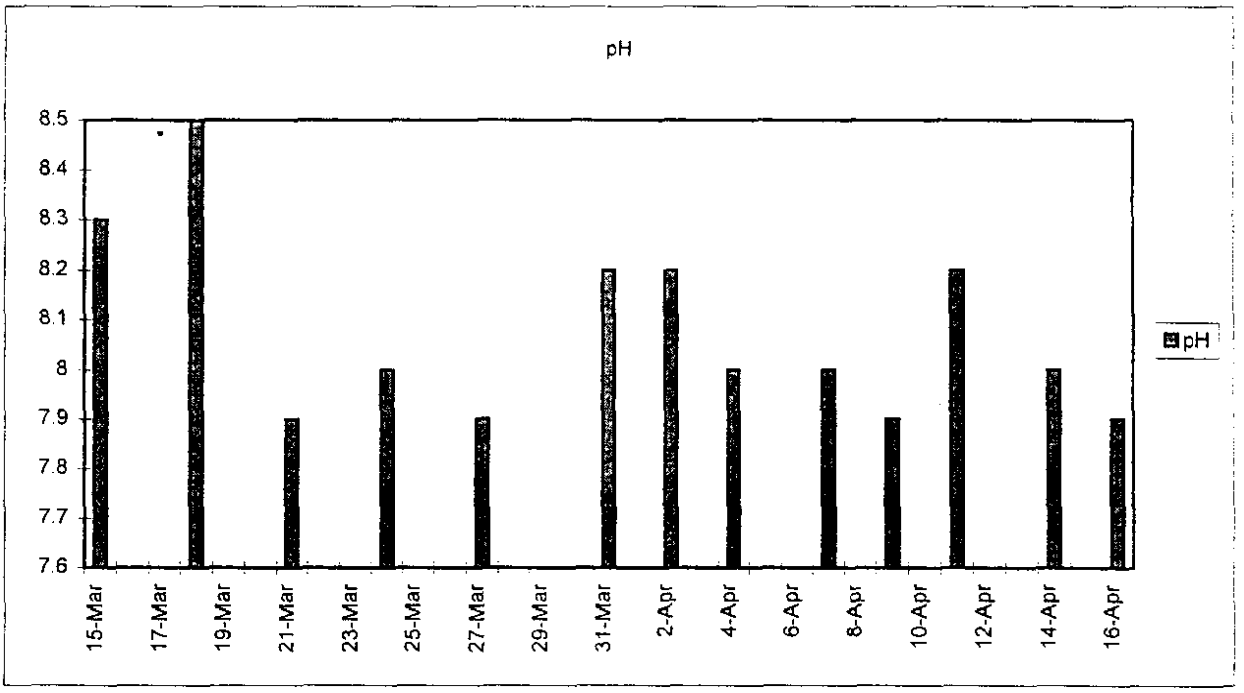
NSWC CRANE
DRY RUN MIX 1
OXYGEN and pH



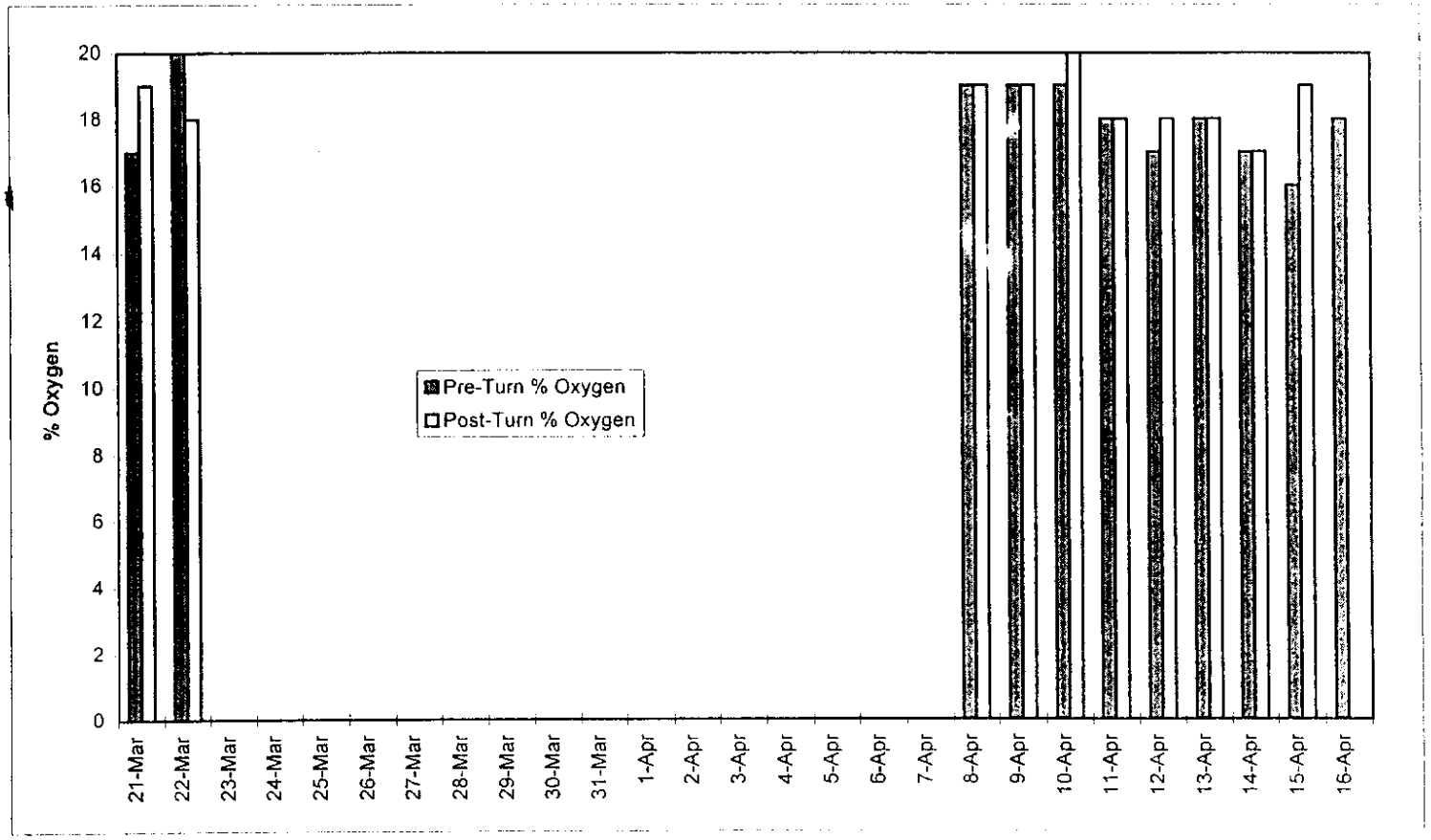


NSWC CRANE
DRY RUN MIX 2
OXYGEN and pH



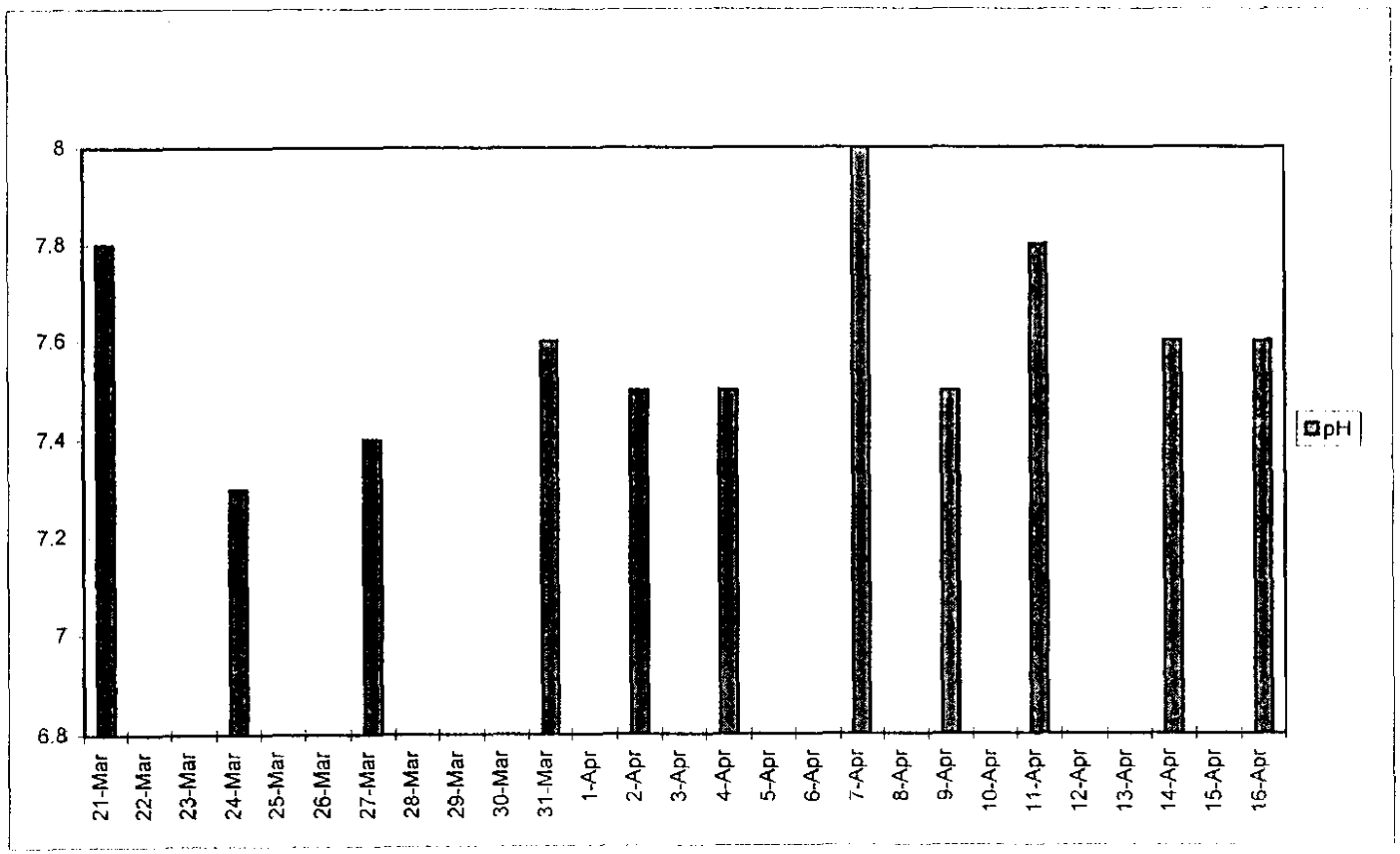


NSWC CRANE
DRY RUN MIX 5
OXYGEN and pH



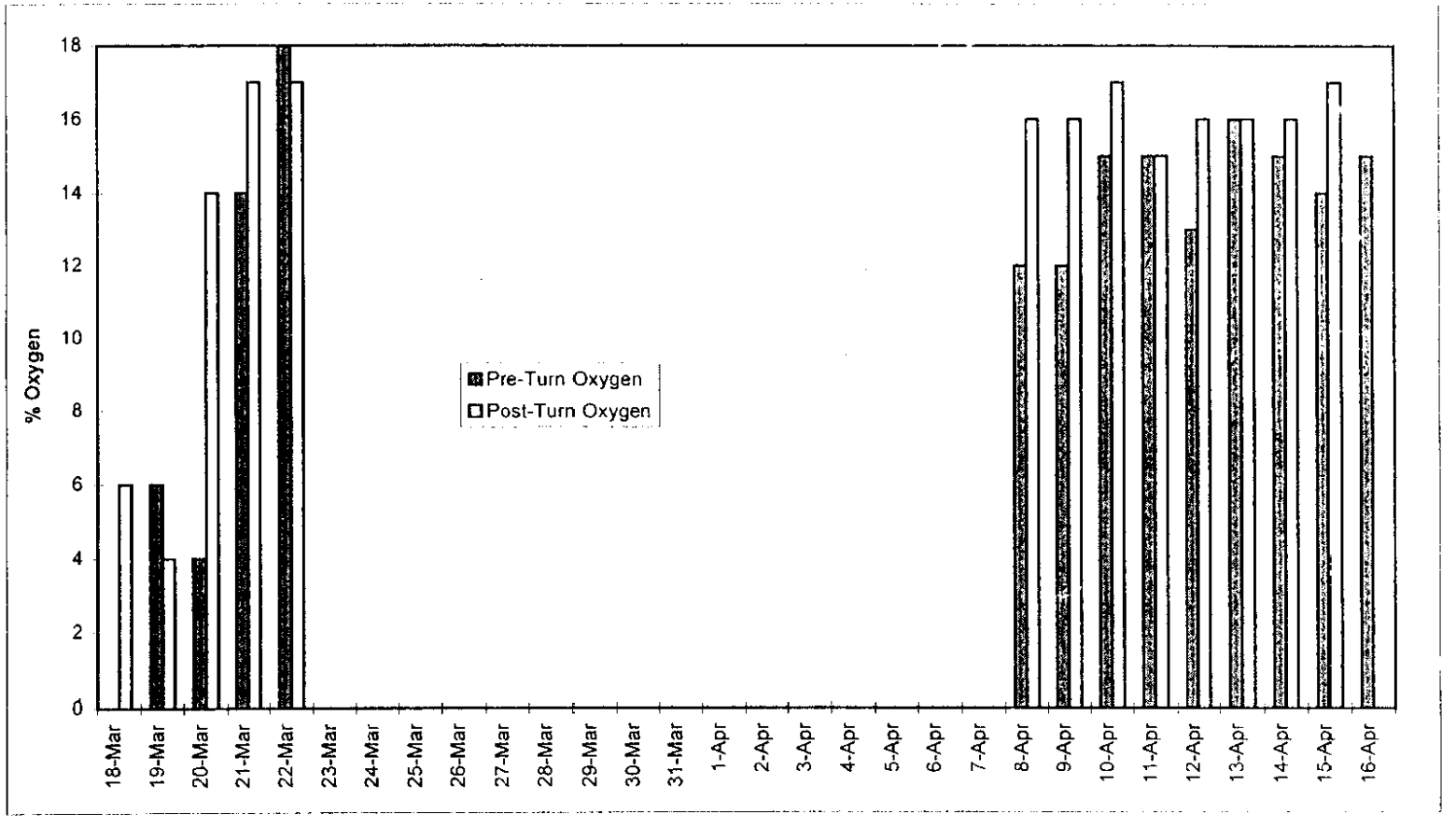
DRMIX5.XLS
Oxygen & pH

NSWC Cr IE
DRY RUN MIX 5
OXYGEN and pH

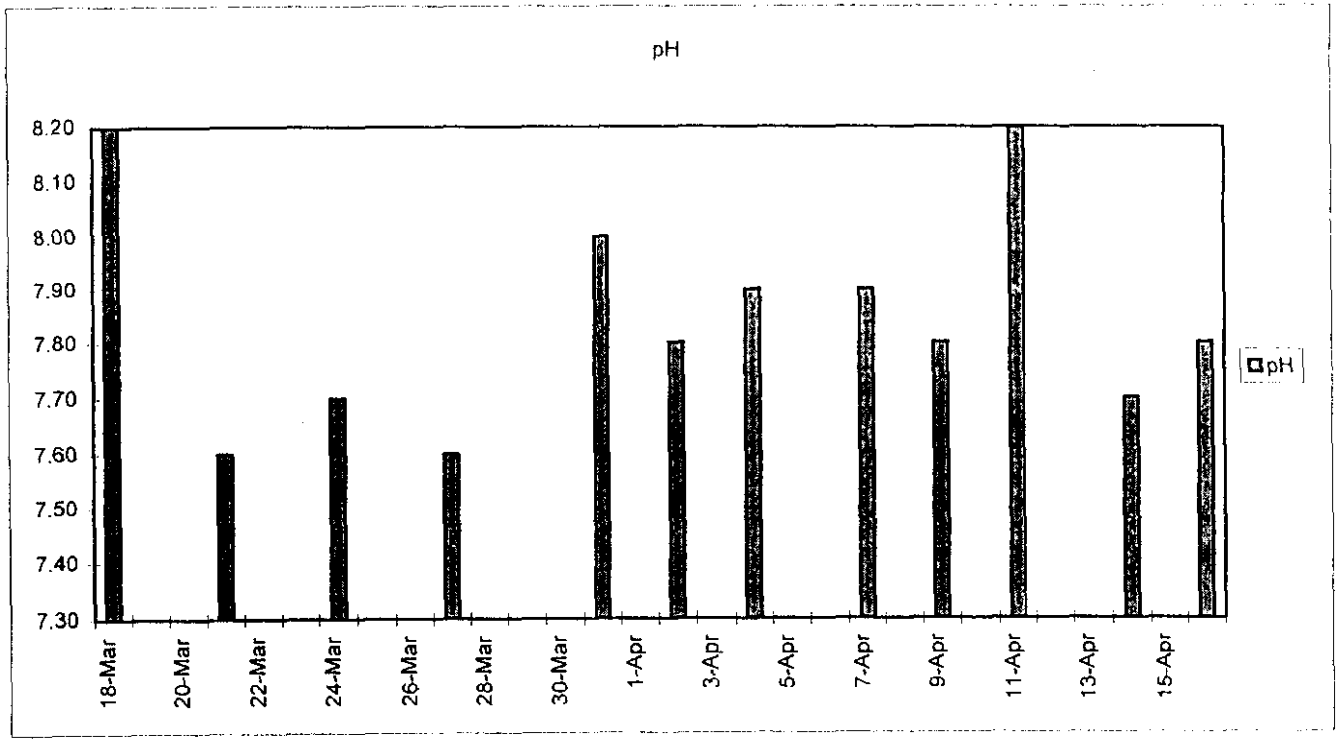


DRMIX5.XLS
Oxygen & pH

NSWC CRANE
DRY RUN MIX 7
OXYGEN and pH



NSWC C. NE
DRY RUN MIX 7
OXYGEN and pH



DRMIX7.XLS
Oxygen & pH

APPENDIX B
RECORD OF RECIPE FORMS

RECORD OF RECIPE

RECIPE # 2 (Bldg 3) **PERFORMED BY:** R. Dayhoff

DATE: 6/27/97 **INSPECTED BY:** T. Dogal

AMENDMENT	DESIGN QUANTITY*		BATCH 1 ACTUAL QUANTITY		BATCH 2 ACTUAL QUANTITY		BATCH ~~2~~ 3 ACTUAL QUANTITY		TOTAL ACTUAL QUANTITY		Supplier
	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds	
Turkey Manure											
Chicken Manure	7	10150	7.9	11410	7.2	10470	6.55	9510	21.65	31390	Wabash Valley Produce/Dayhoff Farms
Cow Manure											
POTW Sludge											
Vegetable Waste											
Alfalfa											
Straw											
Wood Chips	8	4240	8.2	4340	7.9	4180	8.2	4340	24.3	12860	Kaho Brothers
Sawdust											
Soil	15	32600	-	-	-	-	-	-	15	32600	NSWC Crane
Total				15750		14650		13850	60.95	76850	

Comments:

RECORD OF RECIPE

RECIPE # 4 (Bldg 3)

DATE: 6/27/97

PERFORMED BY: R. Dayhoff

INSPECTED BY: T. Dogal

AMENDMENT	DESIGN QUANTITY		BATCH 1 ACTUAL QUANTITY		BATCH 2 ACTUAL QUANTITY		BATCH ~~2~~ 3 ACTUAL QUANTITY		TOTAL ACTUAL QUANTITY		Supplier
	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds	
Turkey Manure											
Chicken Manure	.65	943	1.0	1450	.62	890	.93	1360	2.5	3700	Wabash Valley Produce/Dayhoff Farms
Cow Manure	4.5	6413	4.4	6240	4.6	6500	4.4	6400	13.4	19140	Lueken Dairy/ Dayhoff Farms
POTW Sludge											
Vegetable Waste	2.15	3225	2.5	3800	2.2	3370	2.1	3100	6.8	10270	Frito Potato Co./ Kambach Feeds
Alfalfa	3.85	520	4.45	600	3.4	460	3.7	500	11.55	1560	Dayhoff Farms
Straw											
Wood Chips											
Sawdust	3.85	1579	4.0	1660	3.9	1580	4.14	1700	12.04	4940	Kaho Brothers
Soil	15	32600	-	-	-	-	-	-	15	32600	NSWC Crane
Total				13750		12800		13060	61.29	72210	

Comments:

RECORD OF RECIPE

RECIPE # 7b (Bldg 3)

PERFORMED BY: R. Dayhoff

DATE: 6/28/97

INSPECTED BY: T. Dogal

AMENDMENT	DESIGN QUANTITY		BATCH 1 ACTUAL QUANTITY		BATCH 2 ACTUAL QUANTITY		BATCH ~~2~~ 3 ACTUAL QUANTITY		TOTAL ACTUAL QUANTITY		Supplier
	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds	
Turkey Manure											
Chicken Manure	9	13050	3.2	4430	3.0	3360	3.0	3260	9.2	11050	Wabash Valley Produce/Dayhoff Farms
Cow Manure											
POTW Sludge											
Vegetable Waste											
Alfalfa											
Straw •	36	2916	[1] 5.8	1750	6.3	1340	6.4	1360	18.5[2]	4450	Dayhoff Farms
Wood Chips											
Sawdust											
Soil	15	32600	-	-	-	-	-	-	15	32600	NSWC Crane
Total			90	6180	9.3	4700	9.4	4620	42.7	48100	

Comments: [1] Before cm added 1.2 bales [2] Volume based on compressed state of straw bale. • 238 lbs/cy vs. 81 lbs/cy

RECORD OF RECIPE

RECIPE # 7c (Bldg 3)

PERFORMED BY: R. Dayhoff

DATE: 6/28/97

INSPECTED BY: T. Dogal

AMENDMENT	DESIGN QUANTITY		BATCH 1 ACTUAL QUANTITY		BATCH 2 ACTUAL QUANTITY		BATCH ~~2~~ 3 ACTUAL QUANTITY		TOTAL ACTUAL QUANTITY		Supplier
	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds	
Turkey Manure											
Chicken Manure	6	8200	1.8	2300	2.2	3360	2.5	4370	6.5	10030	Wabash Valley Produce/Dayhoff Farms
Cow Manure											
POTW Sludge											
Vegetable Waste	6	9000	20	3430	2.5	4420	2.3	4460	6.8	12310	Frito Lay Potato/ Kambach Feeds
Alfalfa											
Straw	33	2673	4.8	1020	4.9	1120	4.9	1150	14.6[1]	3390	Dayhoff Farms
Wood Chips											
Sawdust											
Soil	15	32600	-	-	-	-	-	-	15	32600	NSWC Crane
Total			18.6	6750	9.6	8900	9.7	9980	42.9	58230	

Comments: [1] Volume based on compressed state of straw bale.

RECORD OF RECIPE

RECIPE # 3 (Bldg 2)

PERFORMED BY: R. Dayhoff

DATE: 6/28/97

INSPECTED BY: T. Dogal

AMENDMENT	DESIGN QUANTITY		BATCH 1 ACTUAL QUANTITY		BATCH 2 ACTUAL QUANTITY		BATCH ~~2~~ 3 ACTUAL QUANTITY		TOTAL ACTUAL QUANTITY		Supplier
	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds	
Turkey Manure	15	11745	5.3	6080	5.6	8180	5.2	5750	16.1	20010	D. Benham Purdue Farms/ Dayhoff Farms
Chicken Manure											
Cow Manure											
POTW Sludge											
Vegetable Waste											
Alfalfa	15	2025	4.7	1070	4.7	1100	4.8	1200	14.2	3370	Dayhoff Farms
Straw											
Wood Chips	15	7950	5.0	2750	5.0	3020	5.0	3050	15	8820	Kaho Brothers
Sawdust											
Soil	15	32600	-	-	-	-	-	-	15	32600	NSWC Crane
Total			14	9900	15	12300		10000	60.3	64800	

Comments:

RECORD OF RECIPE

RECIPE # 5 (Bldg 2)

PERFORMED BY: C. Kixmiller

DATE: 6/29/97

INSPECTED BY: T. Dogal

AMENDMENT	DESIGN QUANTITY		BATCH 1 ACTUAL QUANTITY		BATCH 2 ACTUAL QUANTITY		BATCH ~~2~~ 3 ACTUAL QUANTITY		TOTAL ACTUAL QUANTITY		Supplier
	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds	
Turkey Manure	15.45	12097	5.25	4600	5.5	6160	5.5	4800	16.25	15560	D. Benham Purdue Farms/ Dayhoff Farms
Chicken Manure											
Cow Manure											
POTW Sludge											
Vegetable Waste	6.45	9675	2.15	1390	2.75	2360	2	2220	6.90	5970	Frito Potato Co./ Kambach Feeds
Alfalfa	11.55	1559	4.0	650	3.85	540	4.0	660	11.85	1850	Dayhoff Farms
Straw											
Wood Chips											
Sawdust	11.55	4736	4.0	1630	3.75	1440	3.75	1430	11.5	4500	Kaho Brothers
Soil	15	32600	-	-	-	-	-	-	15	32600	NSWC Crane
Total			15.2	8270	15.85	10500	15.25	9110	61.5	60480	

Comments: Added amendments based on overall dimensions of windrow. Added 3 cyds Turkey manure; 3.5 cyd/700 lb alfalfa; 3 cyd sawdust 6/30/97

RECORD OF RECIPE

RECIPE # 6 (Bldg 2) **PERFORMED BY:** C. Kixmiller

DATE: 6/29/97 **INSPECTED BY:** T. Dogal

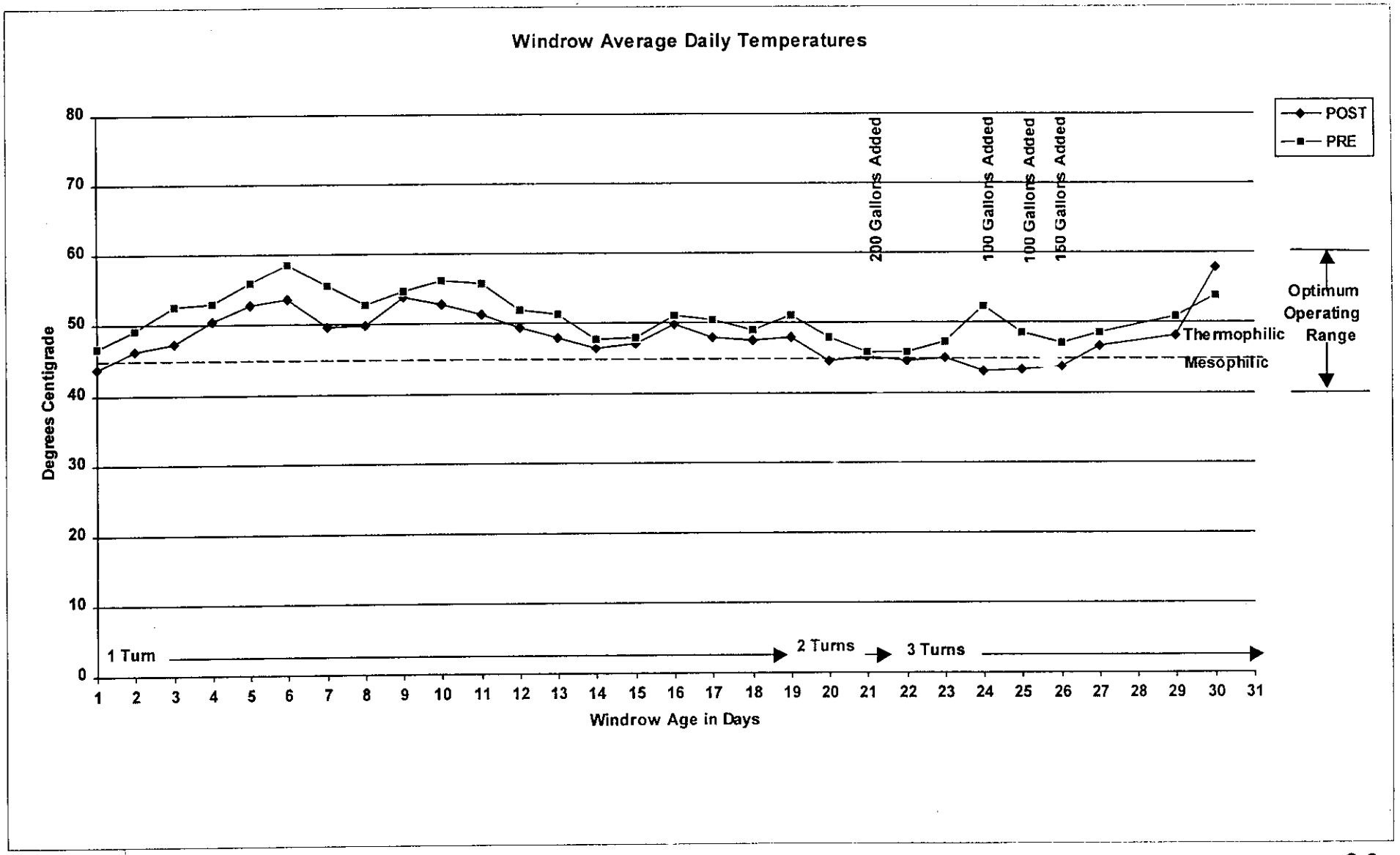
AMENDMENT	DESIGN QUANTITY		BATCH 1 ACTUAL QUANTITY		BATCH 2 ACTUAL QUANTITY		BATCH ~~2~~ 3 ACTUAL QUANTITY		TOTAL ACTUAL QUANTITY		Supplier
	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds	cubic yards	pounds	
Turkey Manure	15	11745	5.50	7300	5.25	7120	5.0	5360	15.75	19780	D. Benham Purdue Farms/ Dayhoff Farms
Chicken Manure											
Cow Manure											
POTW Sludge											
Vegetable Waste	9	13500	3.75	4240	3.25	4060	4.25	5850	11.25	14750	Frito Potato Co./ Kambach Feeds
Alfalfa	9	1215	3.50	630	3.25	580	3	400	9.75	1610	Dayhoff Farms
Straw											
Wood Chips	6	3180	3	1200	2.75	500	2.25	1140	8.0	2840	
Sawdust	6	2460	2.50	870	3.50	1540	3.75	950	8.75	3360	Kaho Brothers
Soil	15	32600	-	-	-	-	-	-	15	32600	NSWC Crane
Total			18.25	14240	18	13800	17.25	13700	68.5	42340	

Comments:

APPENDIX C
TEMPERATURE DATA AND GRAPHS

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 2 Constructed June 28, 1997



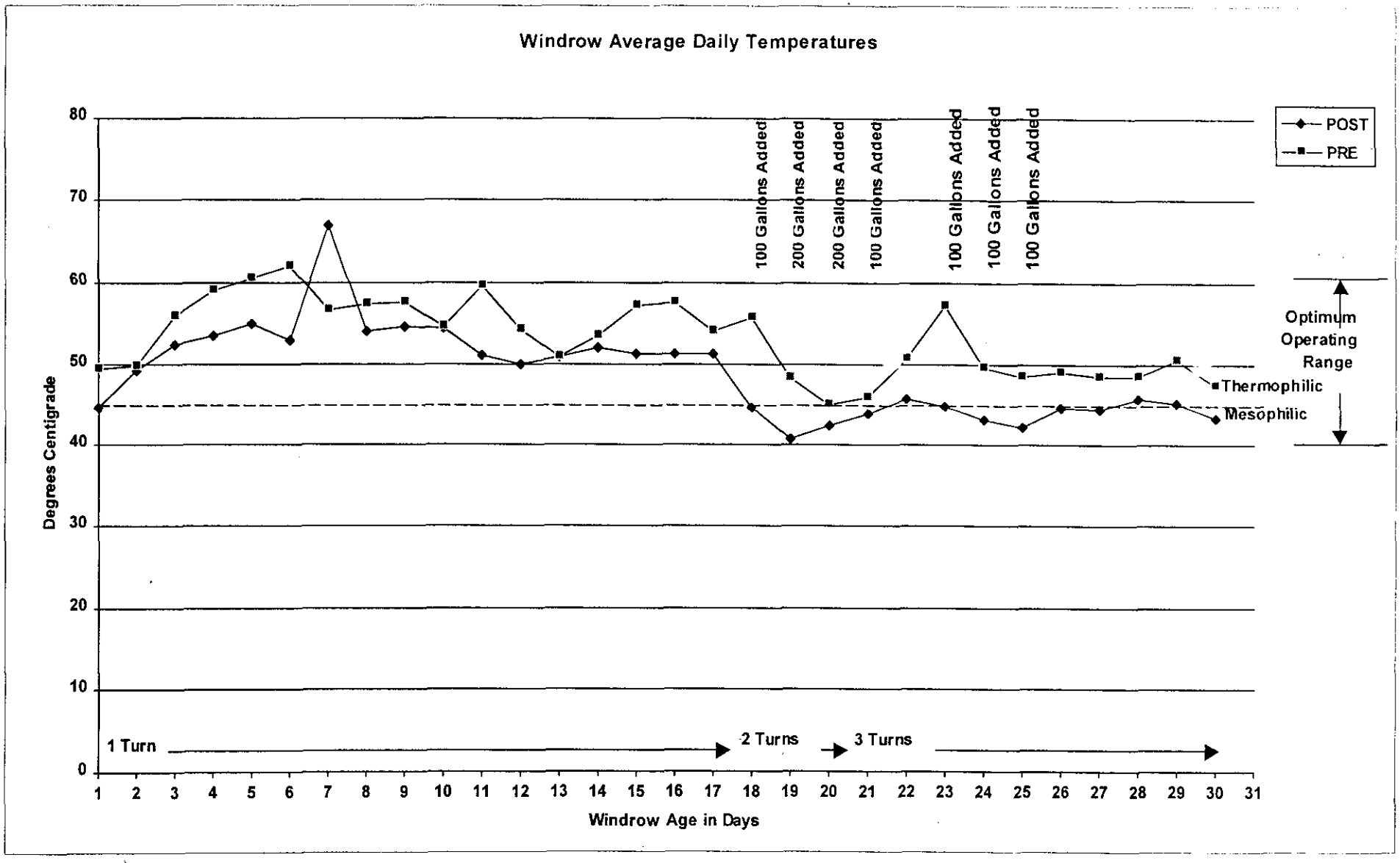
Average Daily Windrow Temperature Summary Report

Windrow Number	Construction Date	Date Monitored	Age (Days)	PRE-Turn (Deg C)	POST-Turn (Deg C)
MIX2	6/28/97	6/29/97	1	46.67	43.79
		6/30/97	2	49.29	46.33
		7/1/97	3	52.71	47.38
		7/2/97	4	52.96	50.46
		7/3/97	5	56.08	52.92
		7/4/97	6	58.50	53.63
		7/5/97	7	55.67	49.75
		7/6/97	8	52.75	49.88
		7/7/97	9	54.79	53.96
		7/8/97	10	56.22	52.79
		7/9/97	11	55.79	51.38
		7/10/97	12	52.04	49.38
		7/11/97	13	51.38	47.96
		7/12/97	14	47.83	46.38
		7/13/97	15	47.96	47.08
		7/14/97	16	51.17	49.96
		7/15/97	17	50.50	48.04
		7/16/97	18	49.00	47.54
		7/17/97	19	51.04	47.96
		7/18/97	20	47.88	44.63
		7/19/97	21	45.79	45.13
		7/20/97	22	45.79	44.50
		7/21/97	23	47.42	45.08
		7/22/97	24	52.33	43.04
		7/23/97	25	48.63	43.21
		7/24/97	26	47.08	43.79
		7/25/97	27	48.67	46.63
		7/27/97	29	50.92	48.17
		7/28/97	30	54.00	57.92

All average temperatures are in degrees centigrade

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 3 Constructed June 29, 1997



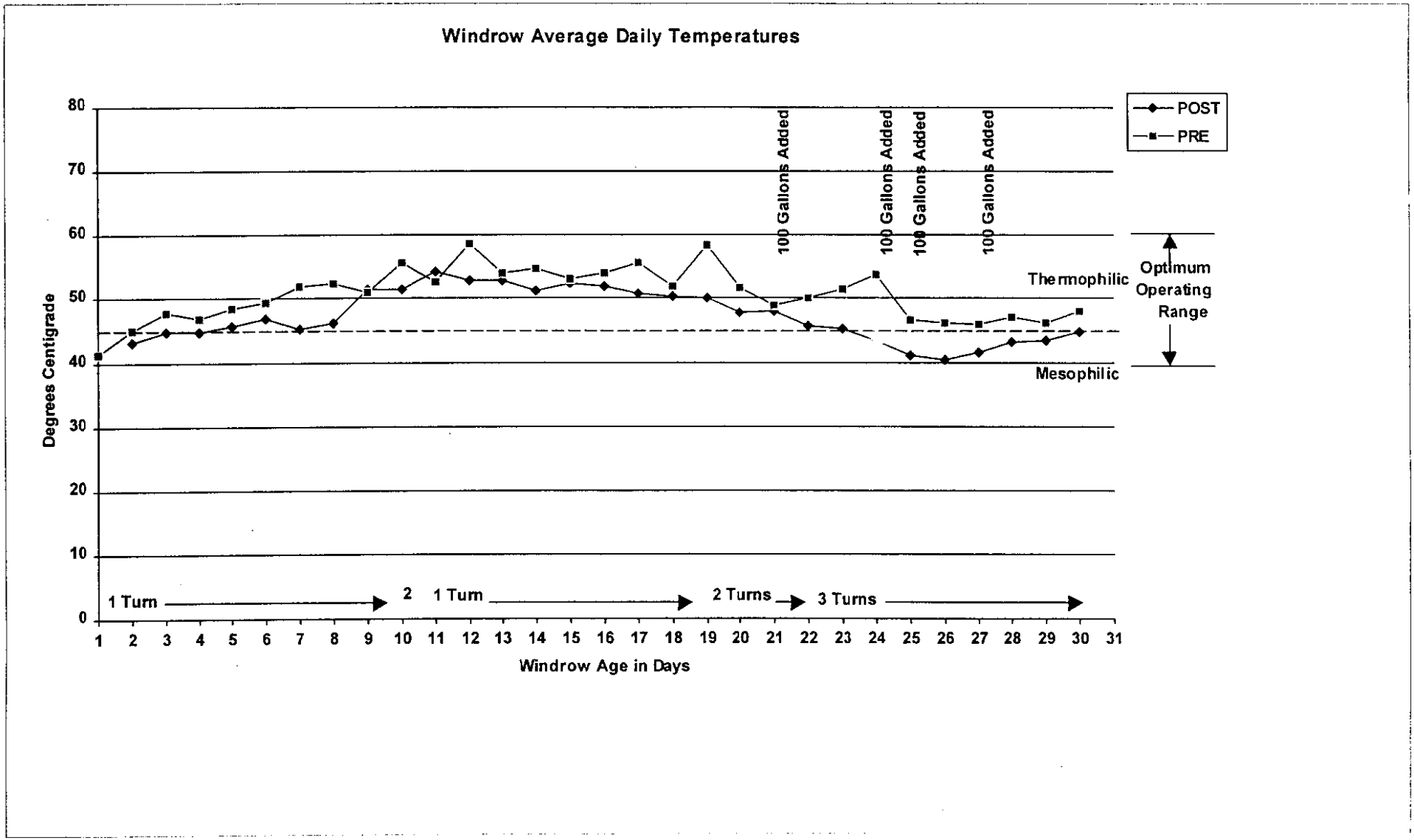
Average Daily Windrow Temperature Summary Report

Windrow Number	Construction Date	Date Monitored	Age (Days)	PRE-Turn (Deg C)	POST-Turn (Deg C)
MIX3	6/29/97	6/30/97	1	49.33	44.63
		7/1/97	2	49.79	49.13
		7/2/97	3	55.79	52.38
		7/3/97	4	59.04	53.50
		7/4/97	5	60.46	54.96
		7/5/97	6	61.88	52.92
		7/6/97	7	56.63	66.96
		7/7/97	8	57.33	53.96
		7/8/97	9	57.50	54.54
		7/9/97	10	54.63	54.38
		7/10/97	11	59.58	51.04
		7/11/97	12	54.21	50.04
		7/12/97	13	50.83	50.79
		7/13/97	14	53.46	52.04
		7/14/97	15	57.17	51.29
		7/15/97	16	57.54	51.29
		7/16/97	17	54.00	51.21
		7/17/97	18	55.71	44.67
		7/18/97	19	48.33	40.79
		7/19/97	20	45.00	42.42
		7/20/97	21	45.83	43.88
		7/21/97	22	50.75	45.71
		7/22/97	23	57.21	44.88
		7/23/97	24	49.63	43.21
		7/24/97	25	48.54	42.21
		7/25/97	26	49.00	44.58
		7/26/97	27	48.46	44.42
		7/27/97	28	48.46	45.63
		7/28/97	29	50.46	45.08
		7/29/97	30	47.29	43.29

All average temperatures are in degrees centigrade

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 4 Constructed June 28, 1997



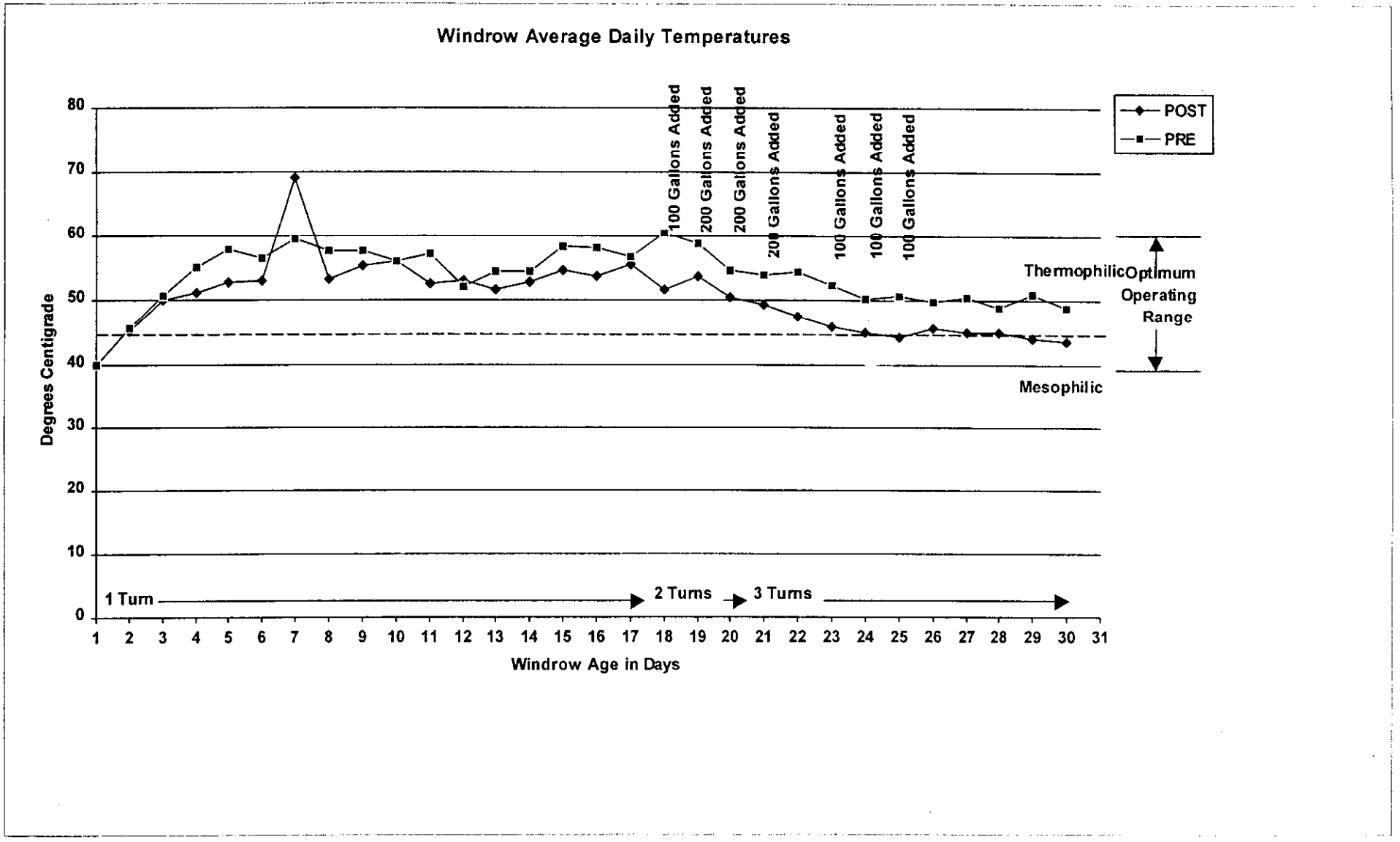
Average Daily Windrow Temperature Summary Report

Windrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*PRE-Turn (Deg C)*	*POST-Turn (Deg C)*
MIX4	6/28/97	6/29/97	1	41.33	
		6/30/97	2	45.00	43.08
		7/1/97	3	47.75	44.[illegible]9
		7/2/97	4	46.88	44.83
		7/3/97	5	48.46	45.75
		7/4/97	6	49.46	46.83
		7/5/97	7	51.83	45.17
		7/6/97	8	52.42	46.25
		7/7/97	9	50.96	51.50
		7/8/97	10	55.54	51.38
		7/9/9[illegible]	11	52.67	54.38
		7/10/97	12	58.75	52.92
		7/11/97	13	53.96	52.96
		7/12/97	14	54.83	51.29
		7/13/97	15	53.08	52.42
		7/14/97	16	54.13	52.00
		7/15/97	17	55.58	50.88
		7/16/97	18	51.88	50.38
		7/17/97	19	58.33	50.04
		7/18/97	20	51.67	47.71
		7/19/97	21	48.83	47.92
		7/20/97	22	50.13	45.71
		7/21/97	23	51.46	45.17
		7/22/97	24	53.88	43.29
		7/23/97	25	46.71	40.96
		7/24/97	26	46.21	40.42
		7/25/97	27	45.83	41.46
		7/26/97	28	47.17	43.04
		7/27/97	29	46.21	43.46
		7/28/97	30	47.92	44.71

All average temperatures are in degrees centigrade

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 5 Constructed June 29, 1997



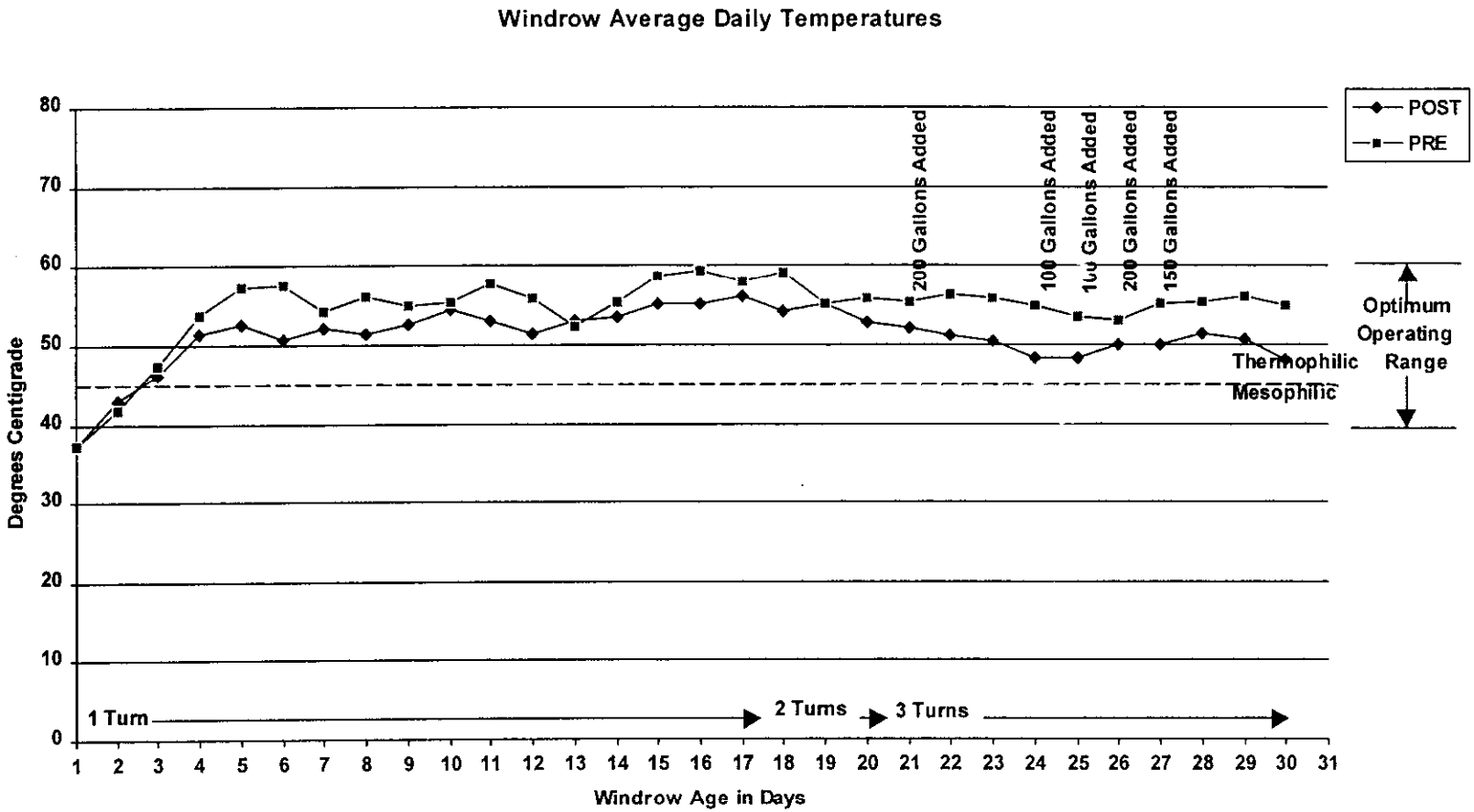
Average Daily Windrow Temperature Summary Report

Windrow Number	Construction Date	Date Monitored	Age (Days)	PRE-Turn (Deg C)	POST-Turn (Deg C)
MiX5	6/29/97	6/30/97	1	40.00	
		7/1/97	2	45.79	45.17
		7/2/97	3	50.75	50.04
		7/3/97	4	55.08	51.17
		7/4/97	5	57.88	52.79
		7/5/97	6	56.63	53.21
		7/6/97	7	59.63	69.13
		7/7/97	8	57.71	53.42
		7/8/97	9	57.67	55.33
		7/9/97	10	56.17	56.08
		7/10/97	11	57.38	52.58
		7/11/97	12	52.08	53.04
		7/12/97	13	54.46	51.71
		7/13/97	14	54.54	52.79
		7/14/97	15	58.50	54.75
		7/15/97	16	58.17	53.83
		7/16/97	17	56.83	55.54
		7/17/97	18	60.58	51.79
		7/18/97	19	58.96	53.83
		7/19/97	20	54.79	50.58
		7/20/97	21	54.13	49.38
		7/21/97	22	54.42	47.63
		7/22/97	23	52.42	45.88
		7/23/97	24	50.42	45.00
		7/24/97	25	50.67	44.21
		7/25/97	26	49.83	45.67
		7/26/97	27	50.50	45.04
		7/27/97	28	48.96	45.00
		7/28/97	29	50.92	44.13
		7/29/97	30	49.04	43.50

All average temperatures are in degrees centigrade

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 6 Constructed June 29, 1997



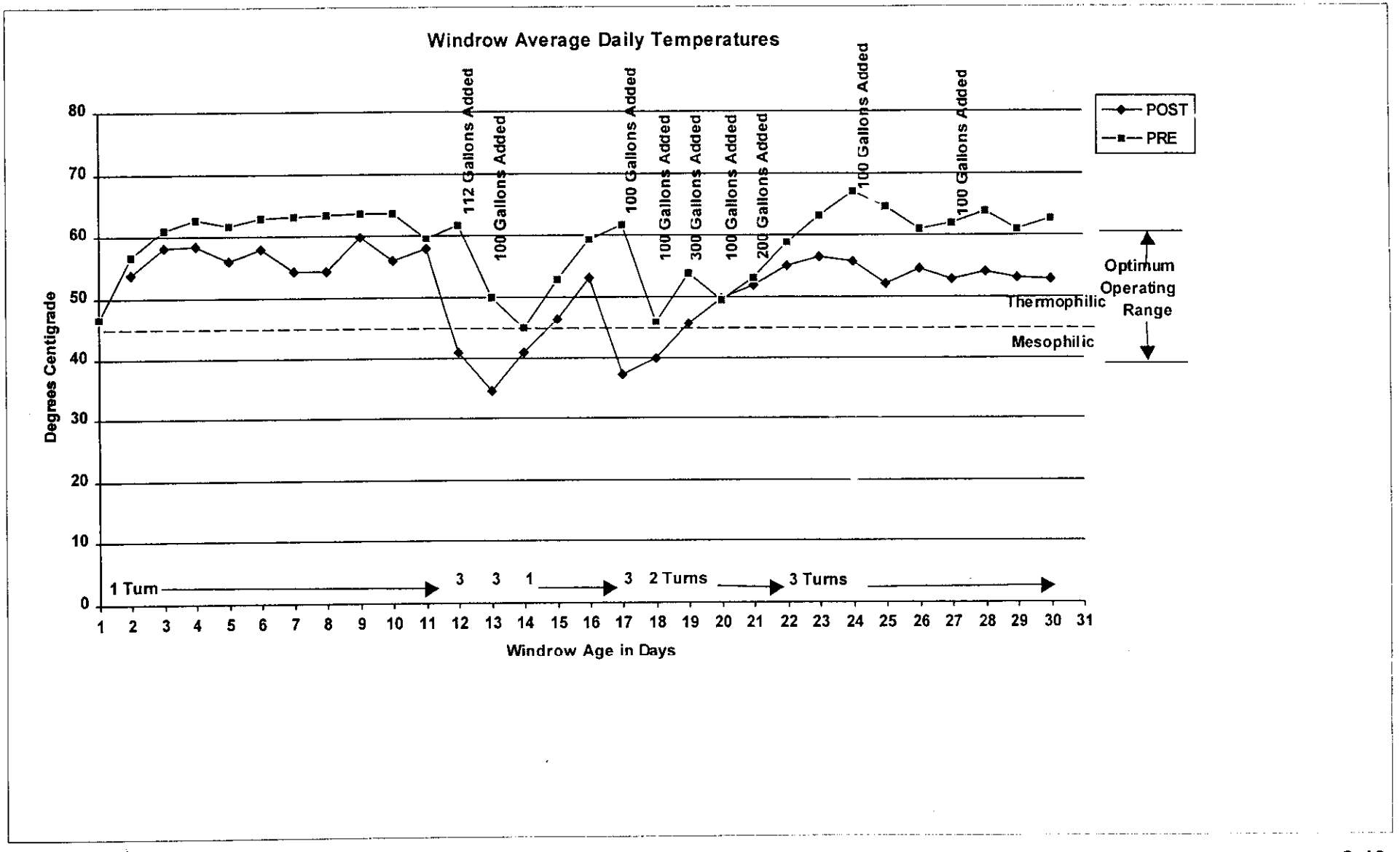
Average Daily Windrow Temperature Summary Report

Vindrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*PRE-Turn (Deg C)*	*POST-Turn (Deg C)*
MIX6	6/29/97	6/30/97	1	37.25	37.21
		7/1/97	2	41.67	43.00
		7/2/97	3	47.33	46.29
		7/3/97	4	53.71	51.38
		7/4/97	5	57.25	52.58
		7/5/97	6	57.50	50.67
		7/6/97	7	54.21	52.17
		7/7/97	8	56.00	51.38
		7/8/97	9	54.88	52.63
		7/9/97	10	55.38	54.46
		7/10/97	11	57.79	53.08
		7/11/97	12	55.79	51.46
		7/12/97	13	52.33	52.96
		7/13/97	14	55.46	53.54
		7/14/97	15	58.75	55.13
		7/15/97	16	59.42	55.17
		7/16/97	17	57.92	55.96
		7/17/97	18	59.21	54.17
		7/18/97	19	55.21	55.21
		7/19/97	20	55.83	52.79
		7/20/97	21	55.33	52.13
		7/21/97	22	56.38	51.25
		7/22/97	23	55.79	50.38
		7/23/97	24	54.96	48.33
		7/24/97	25	53.38	48.29
		7/25/97	26	53.13	50.08
		7/26/97	27	55.04	49.92
		7/27/97	28	55.38	51.29
		7/28/97	29	56.17	50.75
		7/29/97	30	54.79	48.17

All average temperatures are in degrees centigrade

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 7B Constructed June 28, 1997



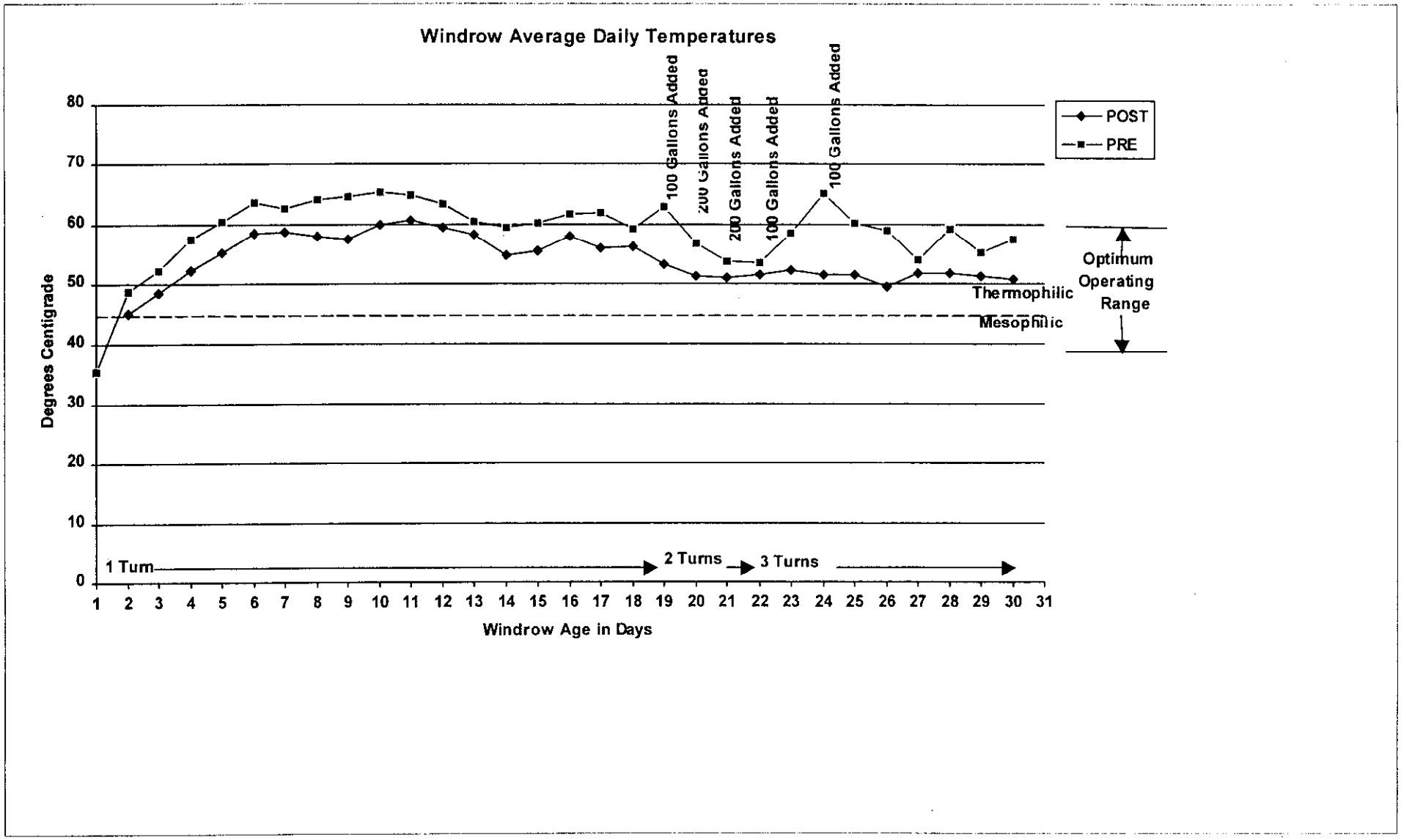
Average Daily Windrow Temperature Summary Report

Vindrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*PRE-Turn (Deg C)*	*POST-Turn (Deg C)*
MIX7B	6/28/97	6/29/97	1	46.71	
		6/30/97	2	56.58	53.79
		7/1/97	3	60.96	58.08
		7/2/97	4	62.71	58.32
		7/3/97	5	61.63	55.88
		7/4/97	6	62.83	57.96
		7/5/97	7	63.21	54.33
		7/6/97	8	63.46	54.29
		7/7/97	9	63.58	59.83
		7/8/97	10	63.75	56.04
		7/9/97	11	59.63	58.00
		7/10/97	12	61.83	40.91
		7/11/97	13	49.96	34.50
		7/12/97	14	44.88	40.96
		7/13/97	15	52.78	46.36
		7/14/97	16	59.28	53.06
		7/15/97	17	61.65	37.21
		7/16/97	18	45.83	39.92
		7/17/97	19	53.92	45.71
		7/18/97	20	49.42	49.79
		7/19/97	21	55.00	51.79
		7/20/97	22	58.83	55.08
		7/21/97	23	63.13	56.50
		7/22/97	24	66.92	55.79
		7/23/97	25	64.67	52.13
		7/24/97	26	61.00	54.63
		7/25/97	27	61.92	52.78
		7/26/97	28	63.88	53.96
		7/27/97	29	60.92	53.17
		7/28/97	30	62.63	52.79

All average temperatures are in degrees centigrade

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 7C Constructed June 28, 1997



Average Daily Windrow Temperature Summary Report

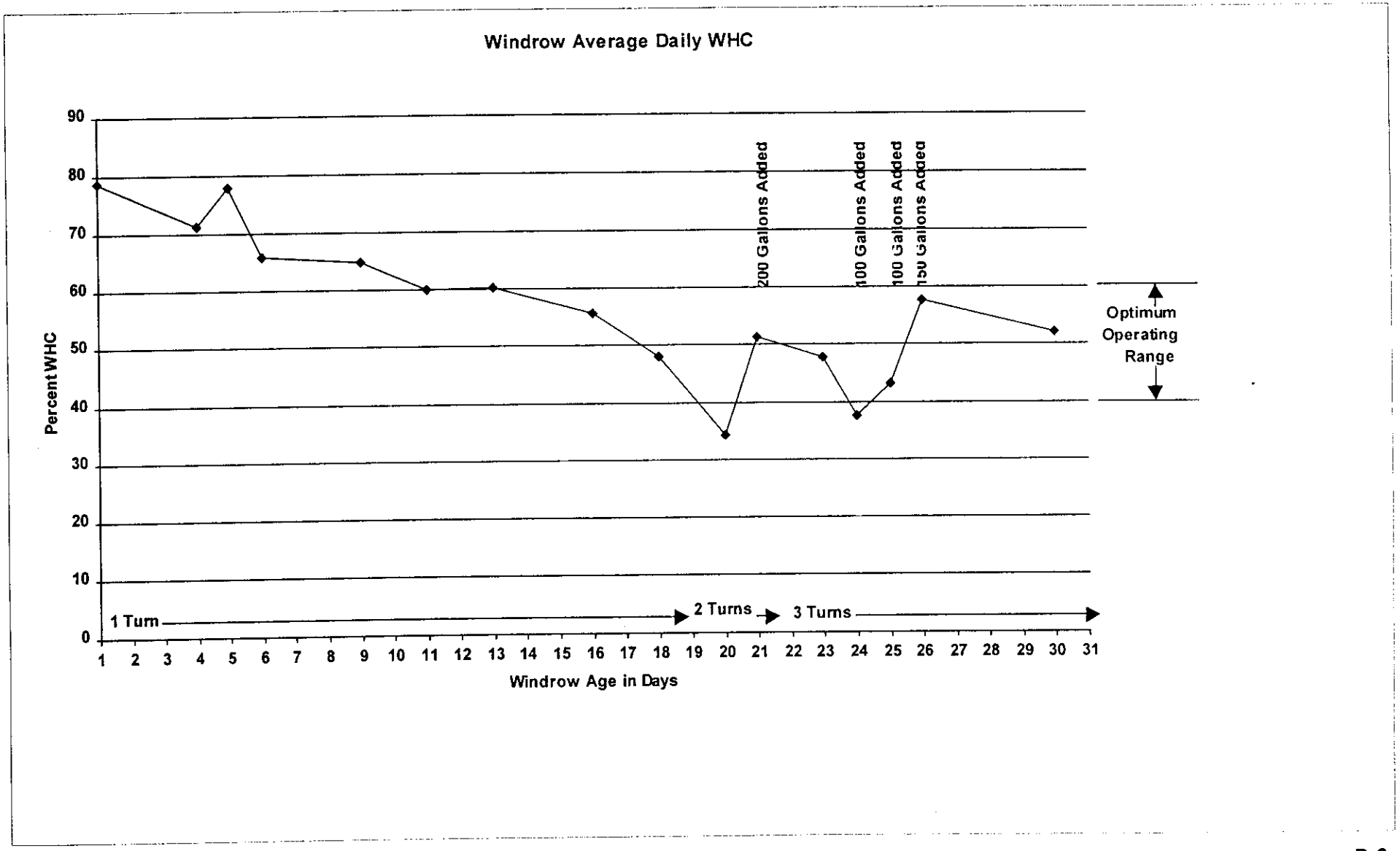
Windrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*PRE-Turn (Deg C)*	*POST-Turn (Deg C)*
MIX7C	6/28/97	6/29/97	1	35.33	
		6/30/97	2	48.71	45.04
		7/1/97	3	52.33	48.54
		7/2/97	4	57.38	52.33
		7/3/97	5	60.42	55.33
		7/4/97	6	63.71	58.33
		7/5/97	7	62.71	58.63
		7/6/97	8	64.25	57.88
		7/7/97	9	64.63	57.54
		7/8/97	10	65.42	60.00
		7/9/97	11	64.83	60.71
		7/10/97	12	63.33	59.50
		7/11/97	13	60.42	58.25
		7/12/97	14	59.38	54.83
		7/13/97	15	60.29	55.58
		7/14/97	16	61.79	57.96
		7/15/97	17	61.96	55.92
		7/16/97	18	59.21	56.33
		7/17/97	19	62.83	53.33
		7/18/97	20	56.71	51.33
		7/19/97	21	53.71	51.08
		7/20/97	22	53.38	51.46
		7/21/97	23	58.33	52.38
		7/22/97	24	65.04	51.46
		7/23/97	25	60.21	51.54
		7/24/97	26	58.92	49.58
		7/25/97	27	54.04	51.79
		7/26/97	28	59.21	51.79
		7/27/97	29	55.25	51.38
		7/28/97	30	57.46	50.83

All average temperatures are in degrees centigrade

APPENDIX D
MOISTURE DATA AND GRAPHS

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 2 Constructed June 28, 1997



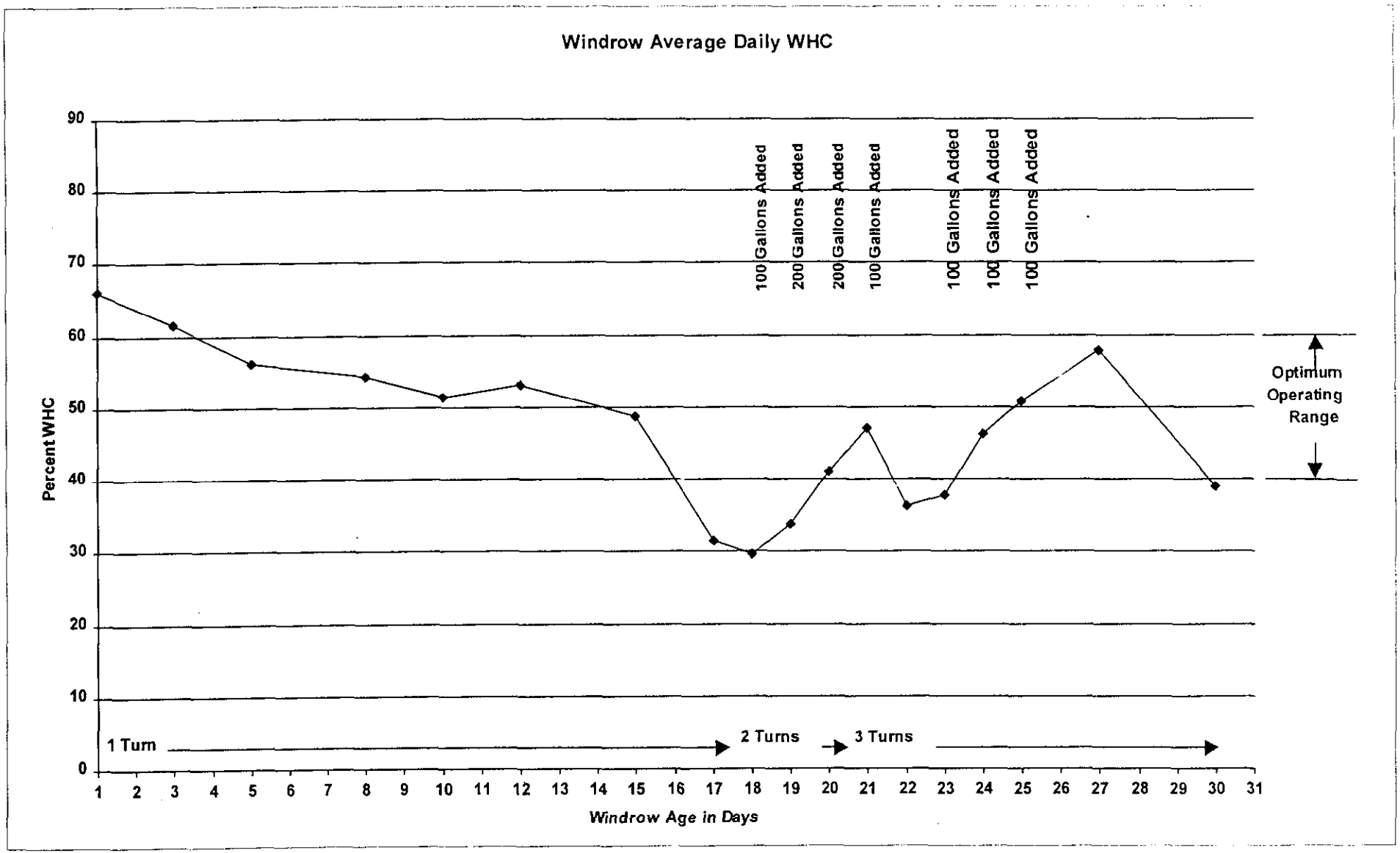
Average Daily Windrow WHC Summary Report

Windrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*PRE-Turn (%)*	*POST-Turn (%)*
MIX2	6/28/97	6/29/97	1	78.75	
		7/2/97	4	71.33	
		7/3/97	5	78.00	
		7/4/97	6	66.00	
		7/7/97	9	65.00	
		7/9/97	11	60.00	
		7/11/97	13	60.25	
		7/14/97	16	55.75	
		7/16/97	18	48.00	
		7/18/97	20	34.33	
		7/19/97	21	51.27	
		7/21/97	23	47.90	
		7/22/97	24		37.70
		7/23/97	25		43.18
		7/24/97	26		57.78
		7/28/97	30	52.17	

All average MWHC values are expressed in percent

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 3 Constructed June 29, 1997



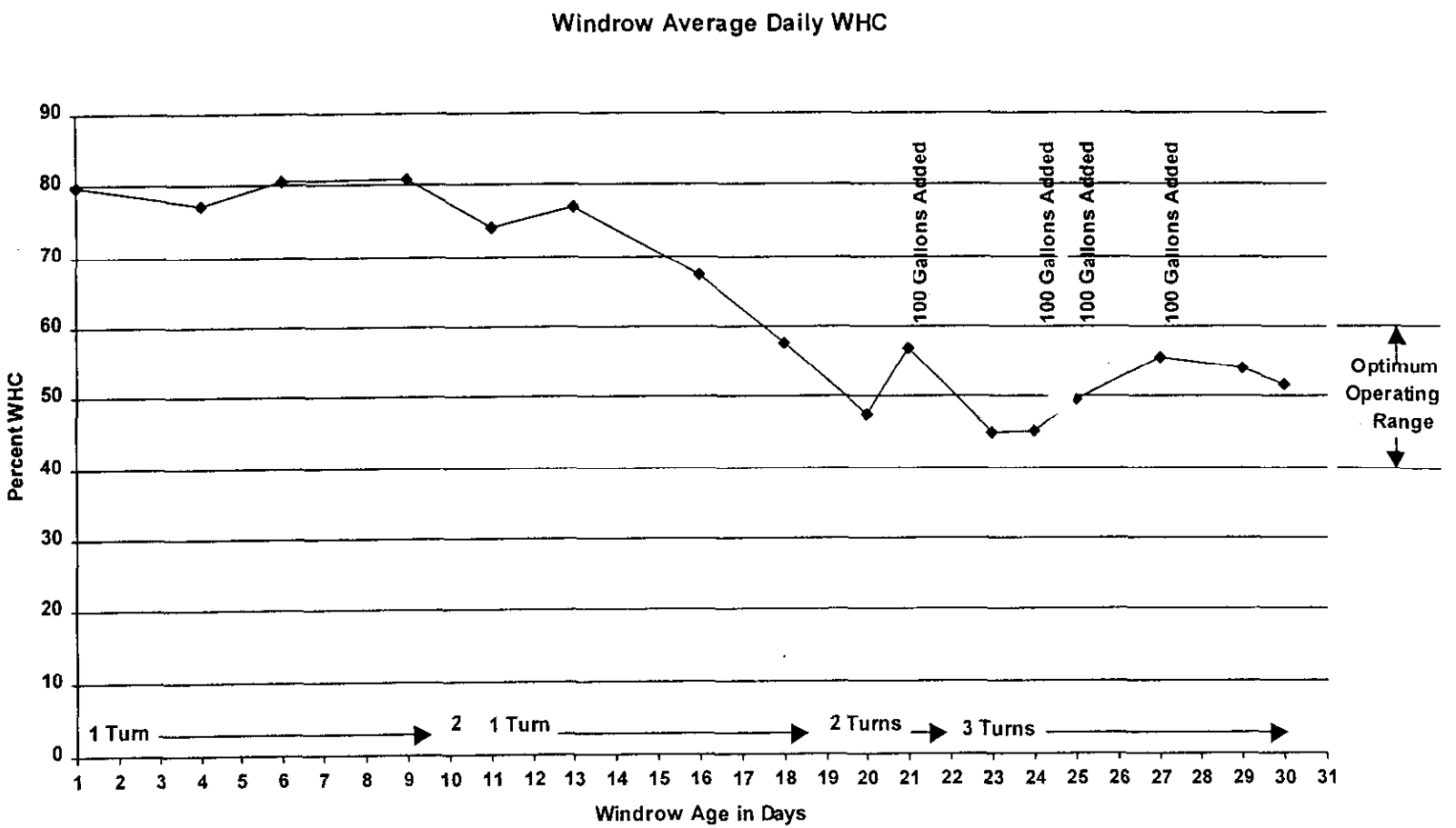
Average Daily Windrow WHC Summary Report

'indrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*PRE-Turn (%)*	*POST-Turn (%)*
MIX3	6/29/97	6/30/97	1	66.25	
		7/2/97	3	61.50	
		7/4/97	5	56.25	
		7/7/97	8	54.25	
		7/9/97	10	51.50	
		7/11/97	12	53.00	
		7/14/97	15	48.75	
		7/16/97	17	31.50	
		7/17/97	18	29.60	
		7/18/97	19	33.75	
		7/19/97	20	40.98	
		7/20/97	21	47.15	
		7/21/97	22	36.20	
		7/22/97	23		37.83
		7/23/97	24		46.27
		7/24/97	25		50.80
		7/26/97	27	57.85	
		7/29/97	30	38.90	

All average MWHC values are expressed in percent

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 4 Constructed June 28, 1997



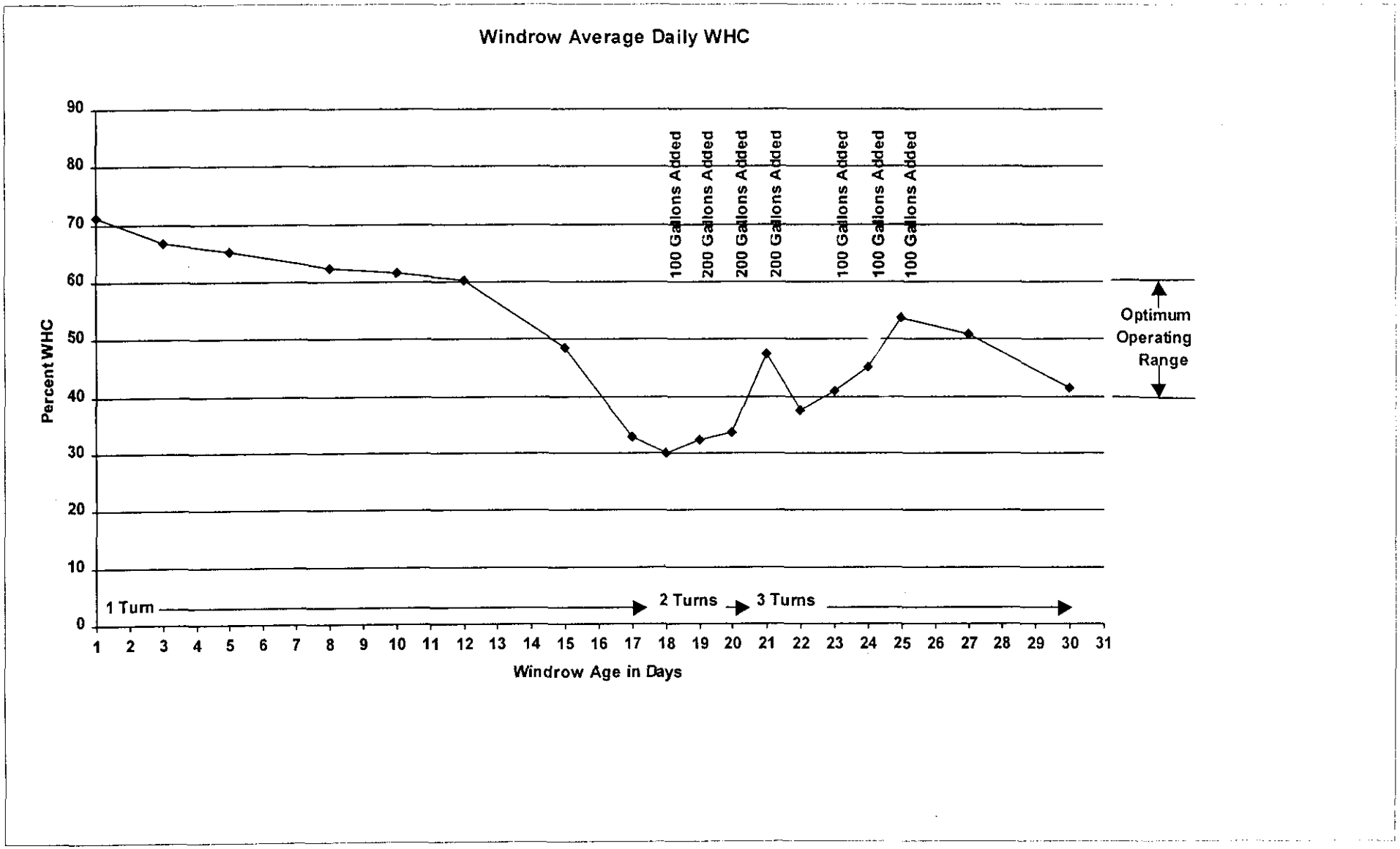
Average Daily Windrow WHC Summary Report

Windrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*PRE-Turn (%)*	*POST-Turn (%)*
MIX4	6/28/97	6/29/97	1	79.75	
		7/2/97	4	77.25	
		7/4/97	6	80.50	
		7/7/97	9	81.00	
		7/9/97	11	74.00	
		7/11/97	13	77.00	
		7/14/97	16	67.25	
		7/16/97	18	57.75	
		7/18/97	20	47.40	
		7/19/97	21	56.88	
		7/21/97	23	44.95	
		7/22/97	24		45.15
		7/23/97	25		49.65
		7/25/97	27		55.65
		7/27/97	29	54.13	
		7/28/97	30	51.63	

All average MWHC values are expressed in percent

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 5 Constructed June 29, 1997



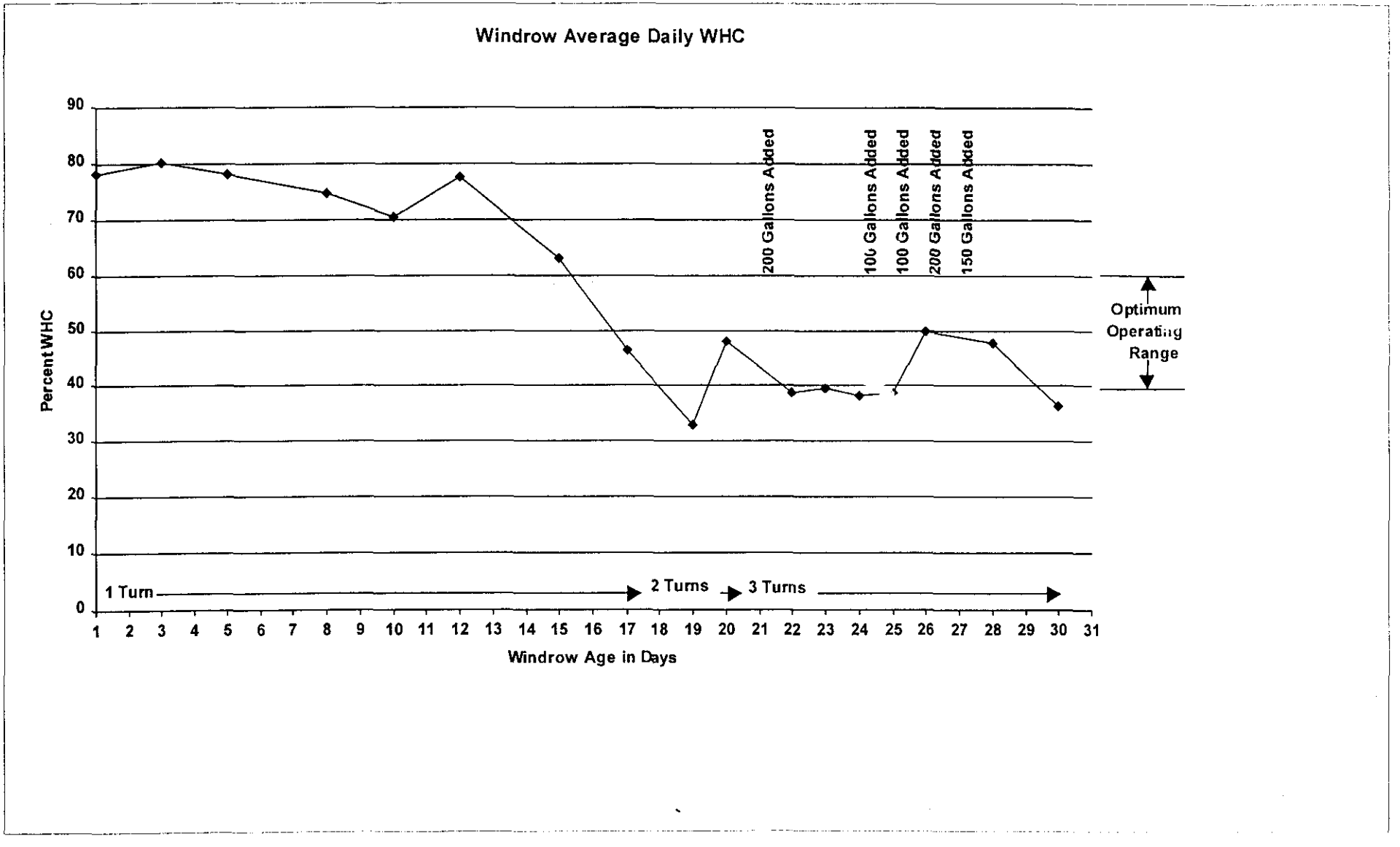
Average Daily Windrow WHC Summary Report

indrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*PRE-Turn (%)*	*POST-Turn (%)*
MIX5	6/29/97	6/30/97	1	71.25	
		7/2/97	3	66.75	
		7/4/97	5	65.25	
		7/7/97	8	62.25	
		7/9/97	10	61.50	
		7/11/97	12	60.25	
		7/14/97	15	48.50	
		7/16/97	17	32.75	
		7/17/97	18	30.10	
		7/18/97	19	32.27	
		7/19/97	20	33.67	
		7/20/97	21	47.50	
		7/21/97	22	37.63	
		7/22/97	23		41.00
		7/23/97	24		45.15
		7/24/97	25		53.73
		7/26/97	27	51.00	
		7/29/97	30	41.60	

All average MWHC values are expressed in percent

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 6 Constructed June 29, 1997



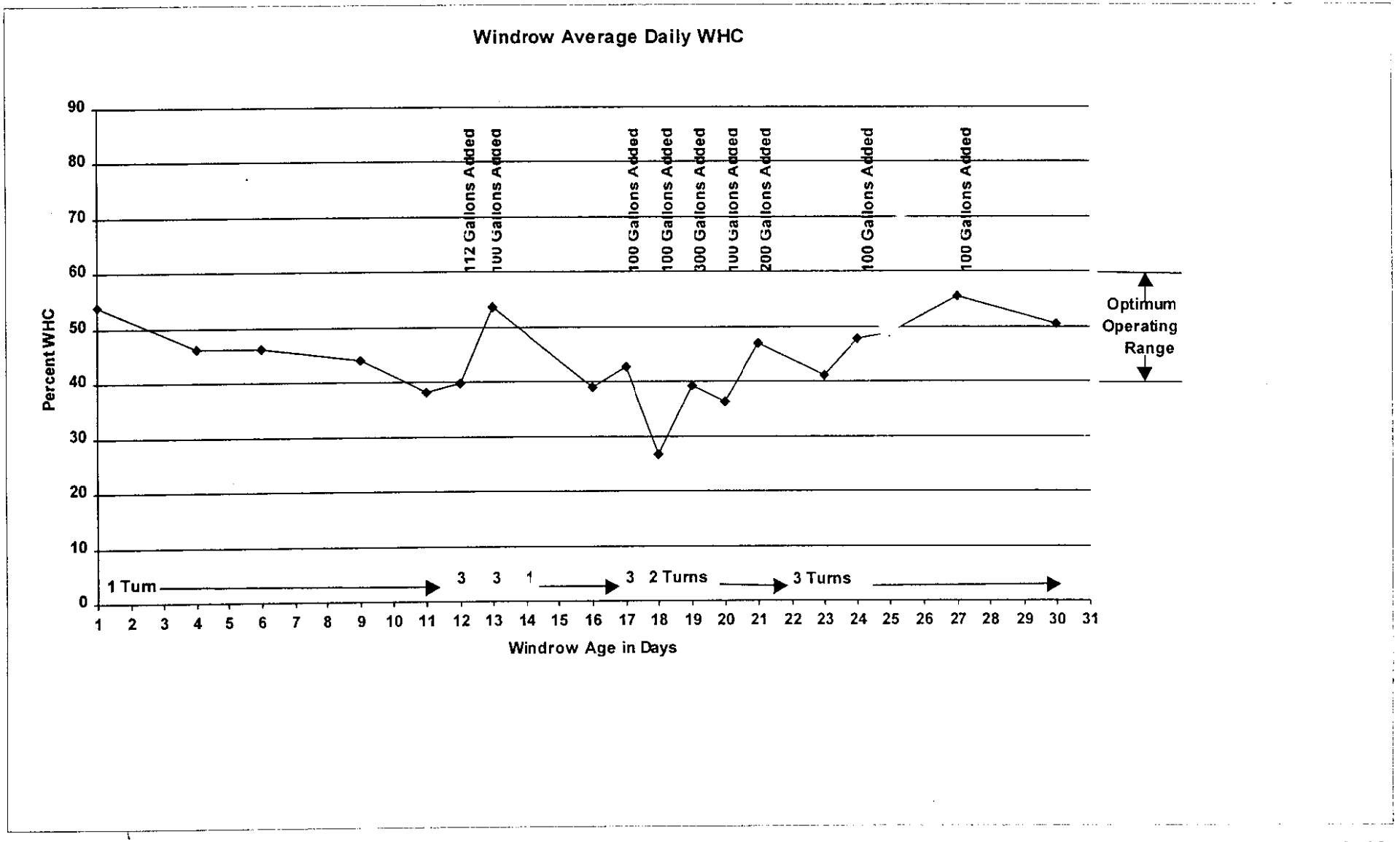
Average Daily Windrow WHC Summary Report

Windrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*PRE-Turn (%)*	*POST-Turn (%)*
MIX6	6/29/97	6/30/97	1	78.25	
		7/2/97	3	80.25	
		7/4/97	5	78.25	
		7/7/97	8	74.75	
		7/9/97	10	70.50	
		7/11/97	12	77.50	
		7/14/97	15	63.00	
		7/16/97	17	46.50	
		7/18/97	19	32.95	
		7/19/97	20	47.97	
		7/21/97	22	38.77	
		7/22/97	23		39.55
		7/23/97	24		38.35
		7/24/97	25		38.92
		7/25/97	26		49.88
		7/27/97	28	47.70	
		7/29/97	30	36.50	

All average MWHC values are expressed in percent

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 7B Constructed June 28, 1997



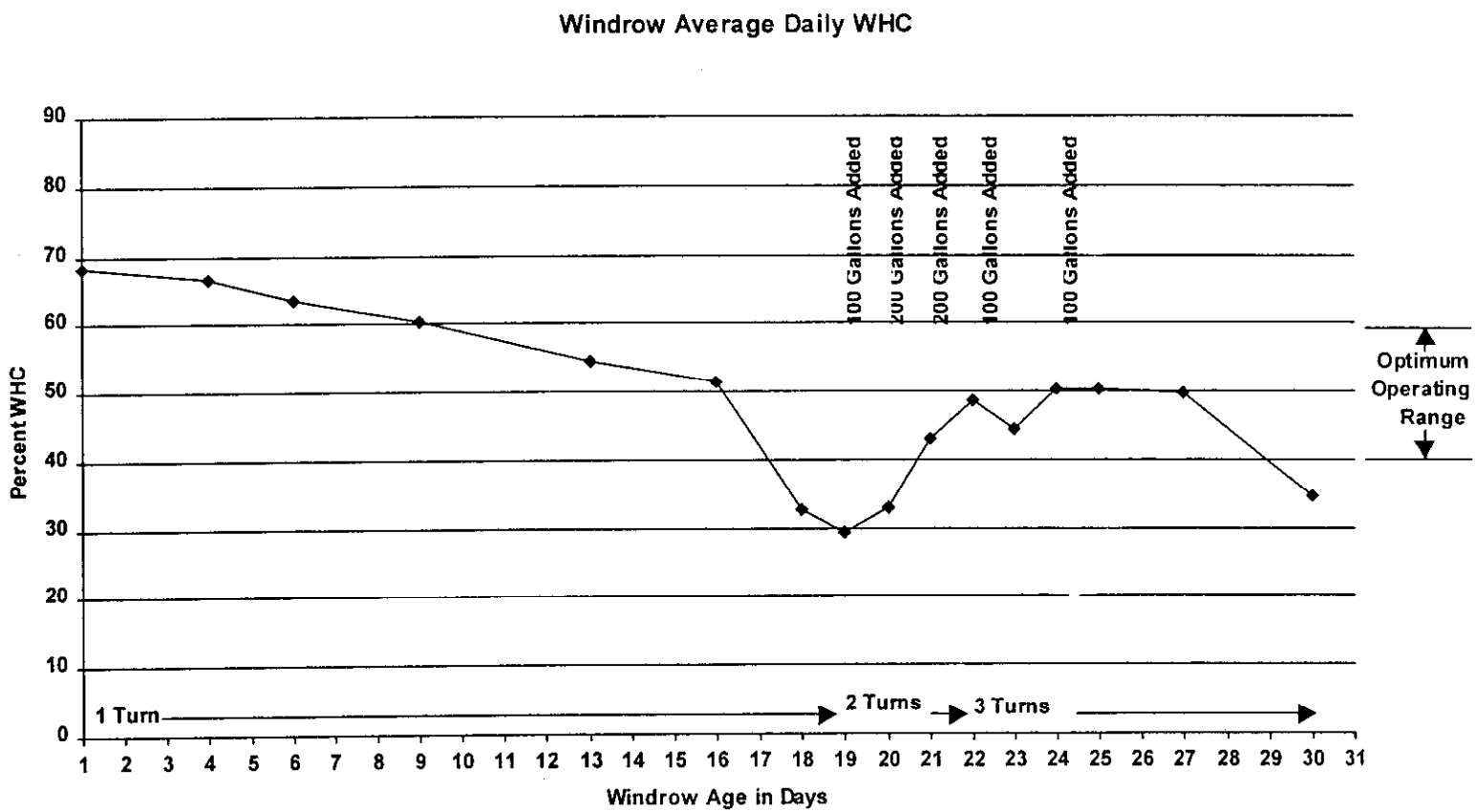
Average Daily Windrow WHC Summary Report

Vindrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*PRE-Turn (%)*	*POST-Turn (%)*
MIX7B	6/28/97	6/29/97	1	54.00	
		7/2/97	4	46.25	
		7/4/97	6	46.25	
		7/7/97	9	44.00	
		7/9/97	11	38.25	
		7 10/97	12		39.75
		7/11/97	13	53.75	
		7/14/97	16	39.00	
		7/15/97	17	42.75	
		7/16/97	18	26.75	
		7/17/97	19	39.25	
		7/18/97	20	36.42	
		7/19/97	21	46.93	
		7/21/97	23	41.00	
		7/22/97	24		47.83
		7/23/97	25		48.85
		7/25/97	27		55.45
		7/28/97	30	50.55	

All average MWHC values are expressed in percent

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 7C Constructed June 28, 1997



Average Daily Windrow WHC Summary Report

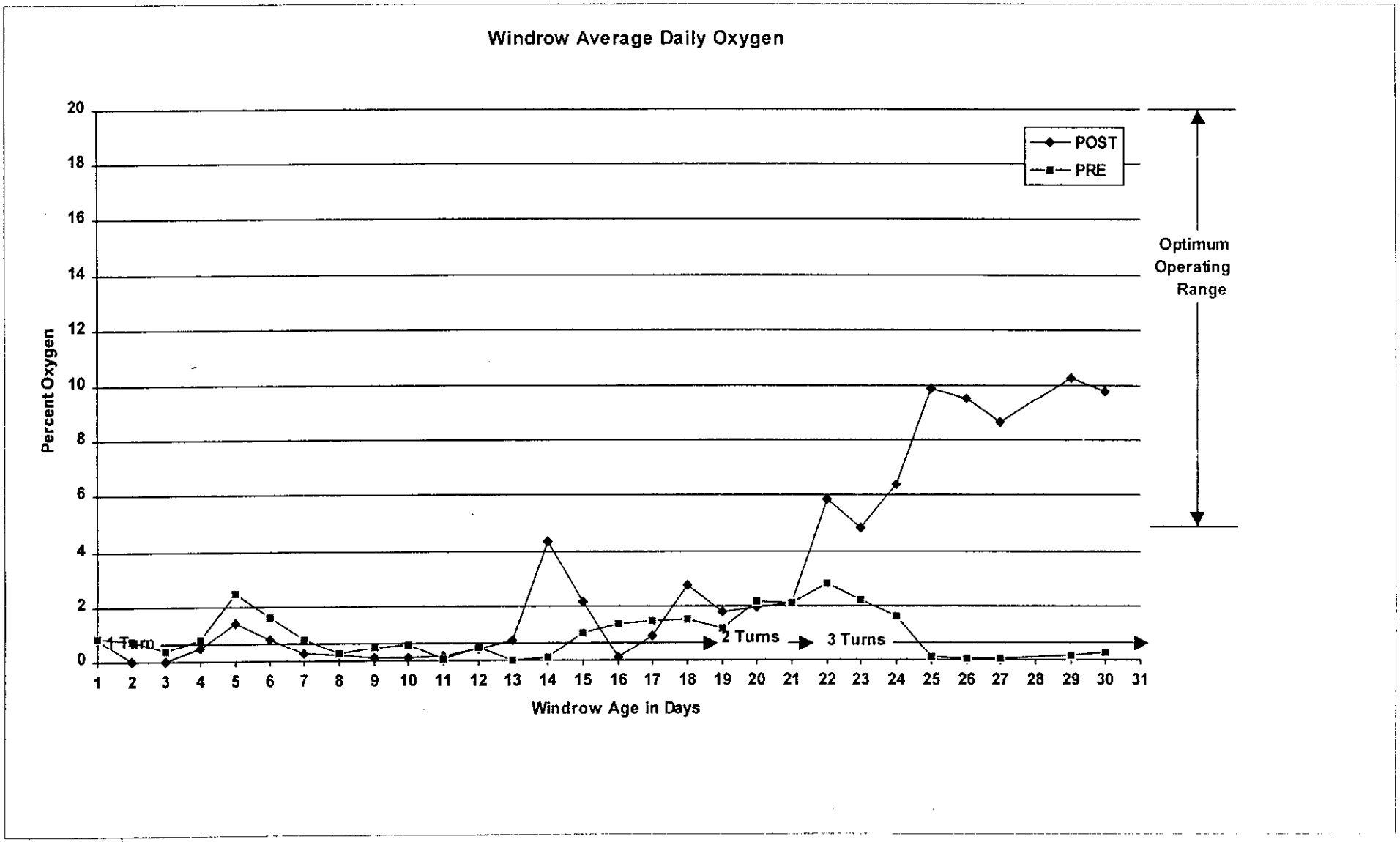
Windrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*PRE-Turn (%)*	*POST-Turn (%)*
MIX7C	6/28/97	6/29/97	1	68.25	
		7/2/97	4	66.50	
		7/4/97	6	63.50	
		7/7/97	9	60.25	
		7/11/97	13	54.50	
		7/14/97	16	51.50	
		7/16/97	18	32.75	
		7/17/97	19	29.33	
		7/18/97	20	33.10	
		7/19/97	21	42.95	
		7/20	22	48.53	
		7/21/97	23	44.35	
		7/22/97	24		50.45
		7/23/97	25		50.23
		7/25/97	27	49.73	
		7/28/97	30	34.73	

All average MWHC values are expressed in percent

APPENDIX E
OXYGEN DATA AND GRAPHS

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 2 Constructed June 28, 1997



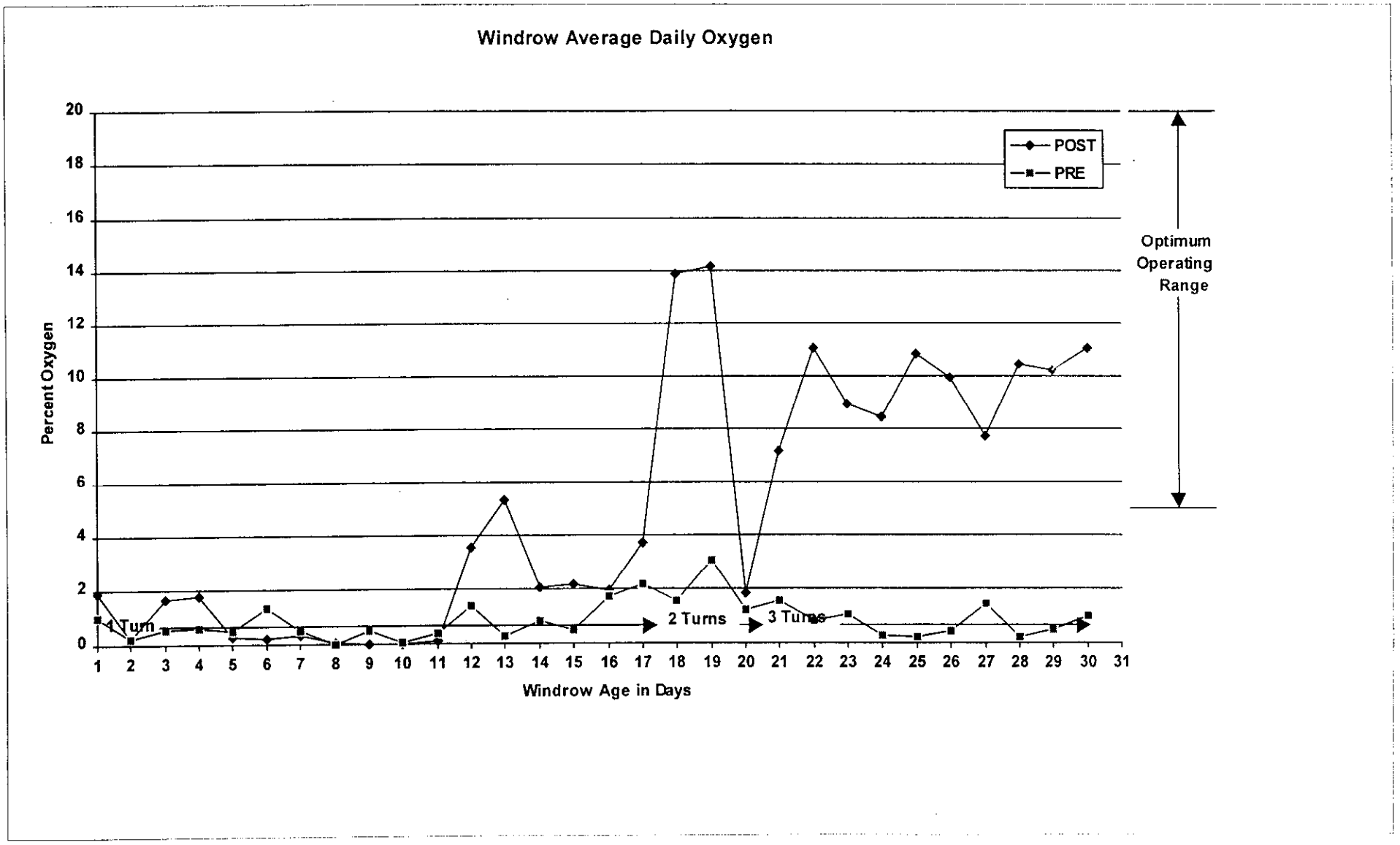
Average Daily Windrow Oxygen Summary Report

Windrow Number	Construction Date	Date Monitored	Age (Days)	PRE-Turn (%)	POST-Turn (%)
MIX2	6/28/97	6/29/97	1	0.88	0.79
		6/30/97	2	0.75	0.00
		7/1/97	3	0.38	0.00
		7/2/97	4	0.83	0.46
		7/3/97	5	2.50	1.42
		7/4/97	6	1.63	0.79
		7/5/97	7	0.83	0.25
		7/6/97	8	0.29	0.21
		7/7/97	9	0.50	0.08
		7/8/97	10	0.61	0.08
		7/9/97	11	0.04	0.17
		7/10/97	12	0.46	0.42
		7/11/97	13	0.00	0.75
		7/12/97	14	0.13	4.38
		7/13/97	15	1.00	2.17
		7/14/97	16	1.33	0.13
		7/15/97	17	1.46	0.92
		7/16/97	18	1.50	2.75
		7/17/97	19	1.21	1.79
		7/18/97	20	2.13	1.92
		7/19/97	21	2.08	2.08
		7/20/97	22	2.79	5.88
		7/21/97	23	2.21	4.83
		7/22/97	24	1.63	6.38
		7/23/97	25	0.08	9.88
		7/24/97	26	0.04	9.54
		7/25/97	27	0.04	8.67
		7/27/97	29	0.17	10.29
		7/28/97	30	0.25	9.79

All average Oxygen values are expressed as a percent

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 3 Constructed June 29, 1997



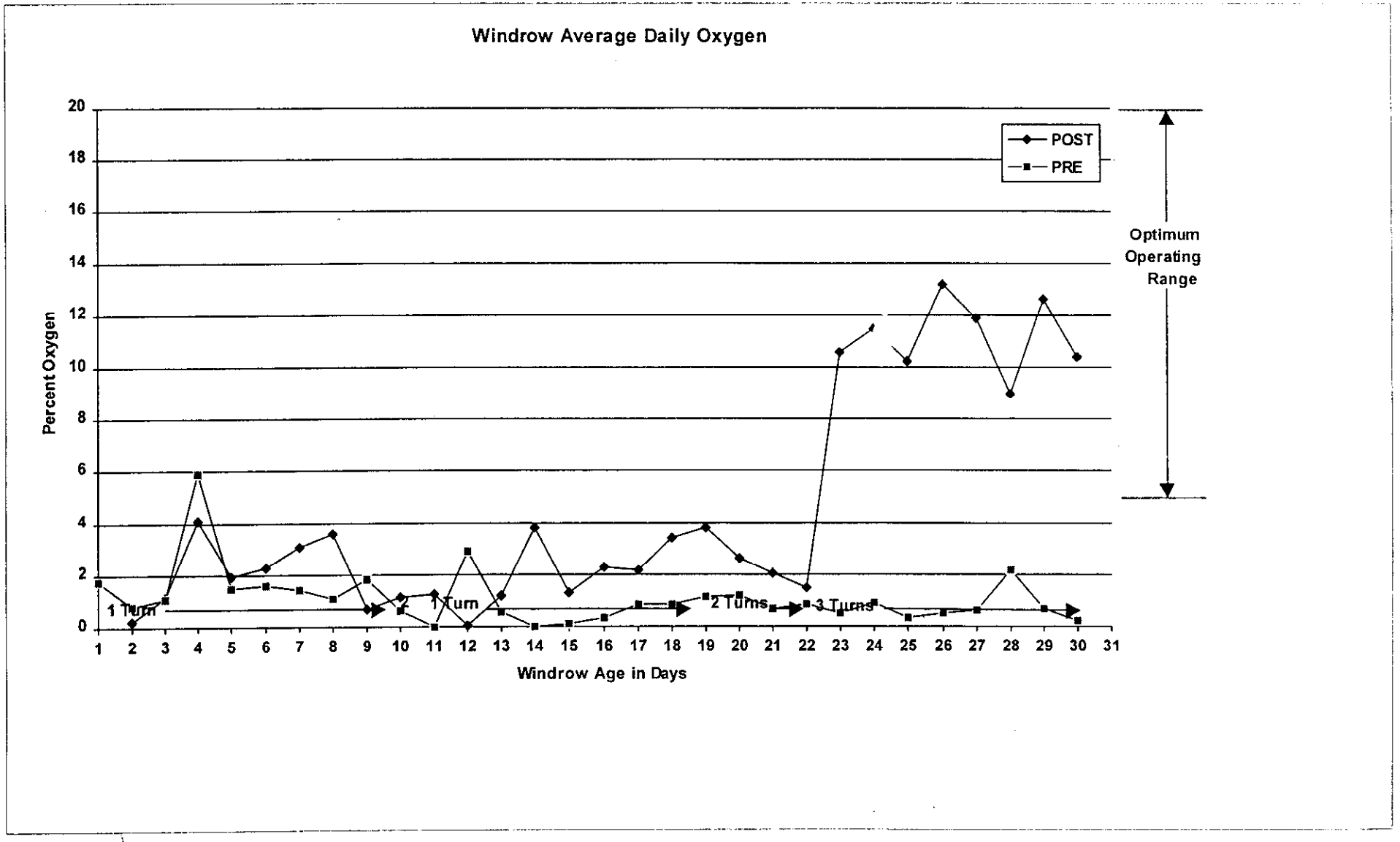
Average Daily Windrow Oxygen Summary Report

'indrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*PRE-Turn (%)*	*POST-Turn (%)*
MIX3	6/29/97	6/30/97	1	1.00	1.88
		7/1/97	2	0.21	0.21
		7/2/97	3	0.54	1.67
		7/3/97	4	0.63	1.79
		7/4/97	5	0.50	0.29
		7/5/97	6	1.33	0.21
		7/6/97	7	0.50	0.33
		7/7/97	8	0.00	0.04
		7/8/97	9	0.50	0.00
		7/9/97	10	0.08	0.00
		7/10/97	11	0.38	0.13
		7/11/97	12	1.38	3.54
		7/12/97	13	0.29	5.33
		7/13/97	14	0.83	2.04
		7/14/97	15	0.50	2.17
		7/15/97	16	1.71	1.96
		7/16/97	17	2.17	3.75
		7/17/97	18	1.54	13.88
		7/18/97	19	3.08	14.17
		7/19/97	20	1.25	1.83
		7/20/97	21	1.54	7.17
		7/21/97	22	0.83	11.04
		7/22/97	23	1.08	8.96
		7/23/97	24	0.29	8.42
		7/24/97	25	0.21	10.83
		7/25/97	26	0.42	9.92
		7/26/97	27	1.42	7.75
		7/27/97	28	0.25	10.42
		7/28/97	29	0.50	10.25
		7/29/97	30	1.00	11.08

All average Oxygen values are expressed as a percent

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 4 Constructed June 28, 1997



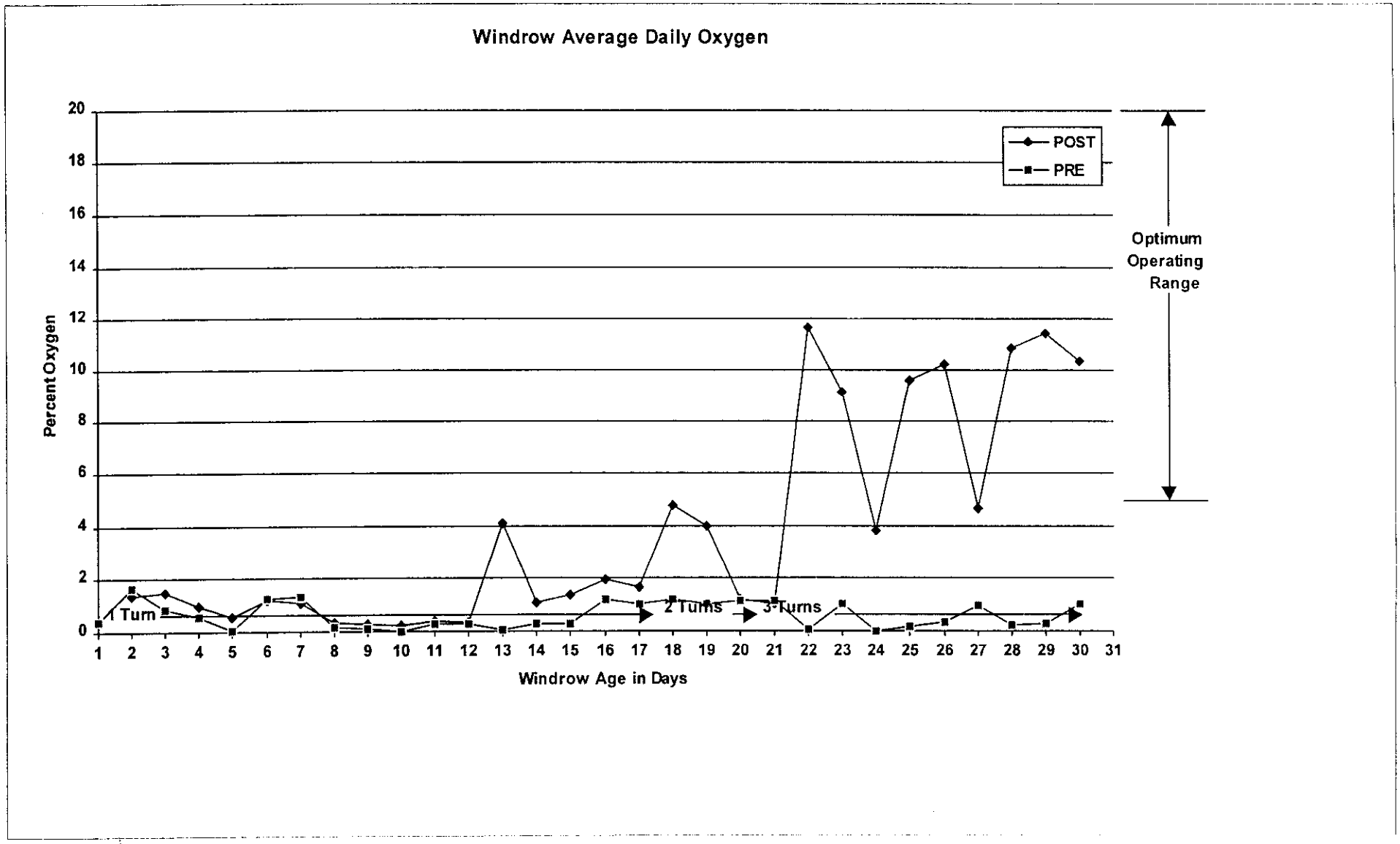
Average Daily Windrow Oxygen Summary Report

'indrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*PRE-Turn (%)*	*POST-Turn (%)*
MIX4	6/28/97	6/29/97	1	1.75	
		6/30/97	2	0.79	0.21
		7/1/97	3	1.08	1.13
		7/2/97	4	5.92	4.08
		7/3/97	5	1.46	1.92
		7/4/97	6	1.58	2.29
		7/5/97	7	1.42	3.08
		7/6/97	8	1.08	3.58
		7/7/97	9	1.83	0.71
		7/8/97	10	0.63	1.13
		7/9/97	11	0.00	1.25
		7/10/97	12	2.88	0.08
		7/11/97	13	0.58	1.21
		7/12/97	14	0.00	3.83
		7/13/97	15	0.13	1.29
		7/14/97	16	0.33	2.25
		7/15/97	17	0.83	2.17
		7/16/97	18	0.83	3.42
		7/17/97	19	1.13	3.79
		7/18/97	20	1.17	2.63
		7/19/97	21	0.71	2.04
		7/20/97	22	0.88	1.46
		7/21/97	23	0.50	10.54
		7/22/97	24	0.92	11.46
		7/23/97	25	0.33	10.25
		7/24/97	26	0.50	13.21
		7/25/97	27	0.63	11.88
		7/26/97	28	2.17	9.00
		7/27/97	29	0.67	12.63
		7/28/97	30	0.25	10.38

All average Oxygen values are expressed as a percent

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 5 Constructed June 29, 1997



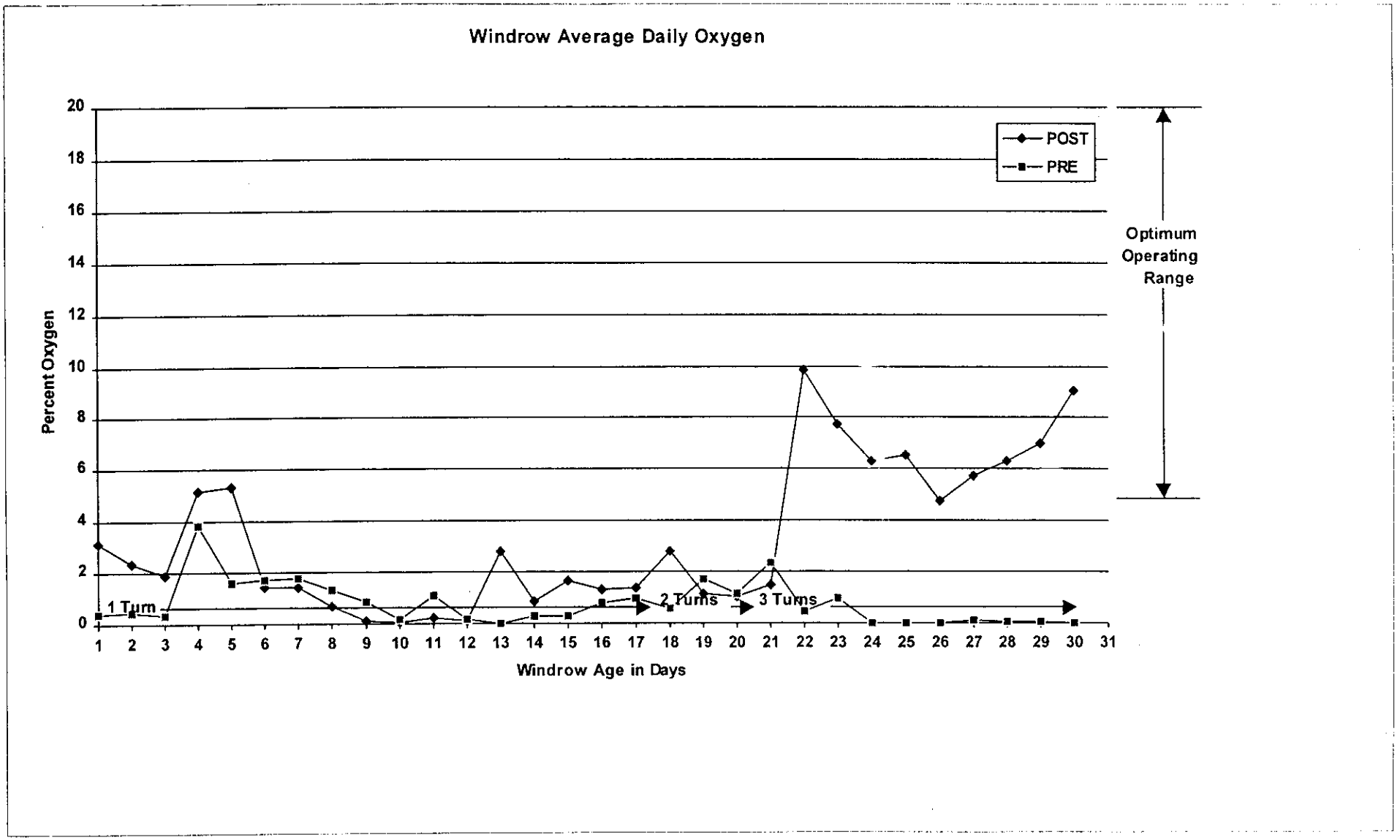
Average Daily Windrow Oxygen Summary Report

indrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*PRE-Turn (%)*	*POST-Turn (%)*
MIX5	6/29/97	6/30/97	1	0.38	
		7/1/97	2	1.65	1.38
		7/2/97	3	0.88	1.46
		7/3/97	4	0.54	0.96
		7/4/97	5	0.04	0.54
		7/5/97	6	1.25	1.17
		7/6/97	7	1.33	1.08
		7/7/97	8	0.17	0.33
		7/8/97	9	0.13	0.29
		7/9/97	10	0.00	0.21
		7/10/	11	0.29	0.42
		7/11/97	12	0.29	0.33
		7/12/97	13	0.04	4.08
		7/13/97	14	0.29	1.08
		7/14/97	15	0.29	1.38
		7/15/97	16	1.17	1.96
		7/16/97	17	1.00	1.67
		7/17/97	18	1.21	4.75
		7/18/97	19	1.00	3.96
		7/19/97	20	1.13	1.17
		7/20/97	21	1.13	1.04
		7/21/97	22	0.08	11.67
		7/22/97	23	1.00	9.13
		7/23/97	24	0.00	3.79
		7/24/97	25	0.17	9.63
		7/25/97	26	0.33	10.25
		7/26/97	27	0.96	4.67
		7/27/97	28	0.21	10.88
		7/28/97	29	0.29	11.42
		7/29/97	30	1.04	10.33

All average Oxygen values are expressed as a percent

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 6 Constructed June 29, 1997



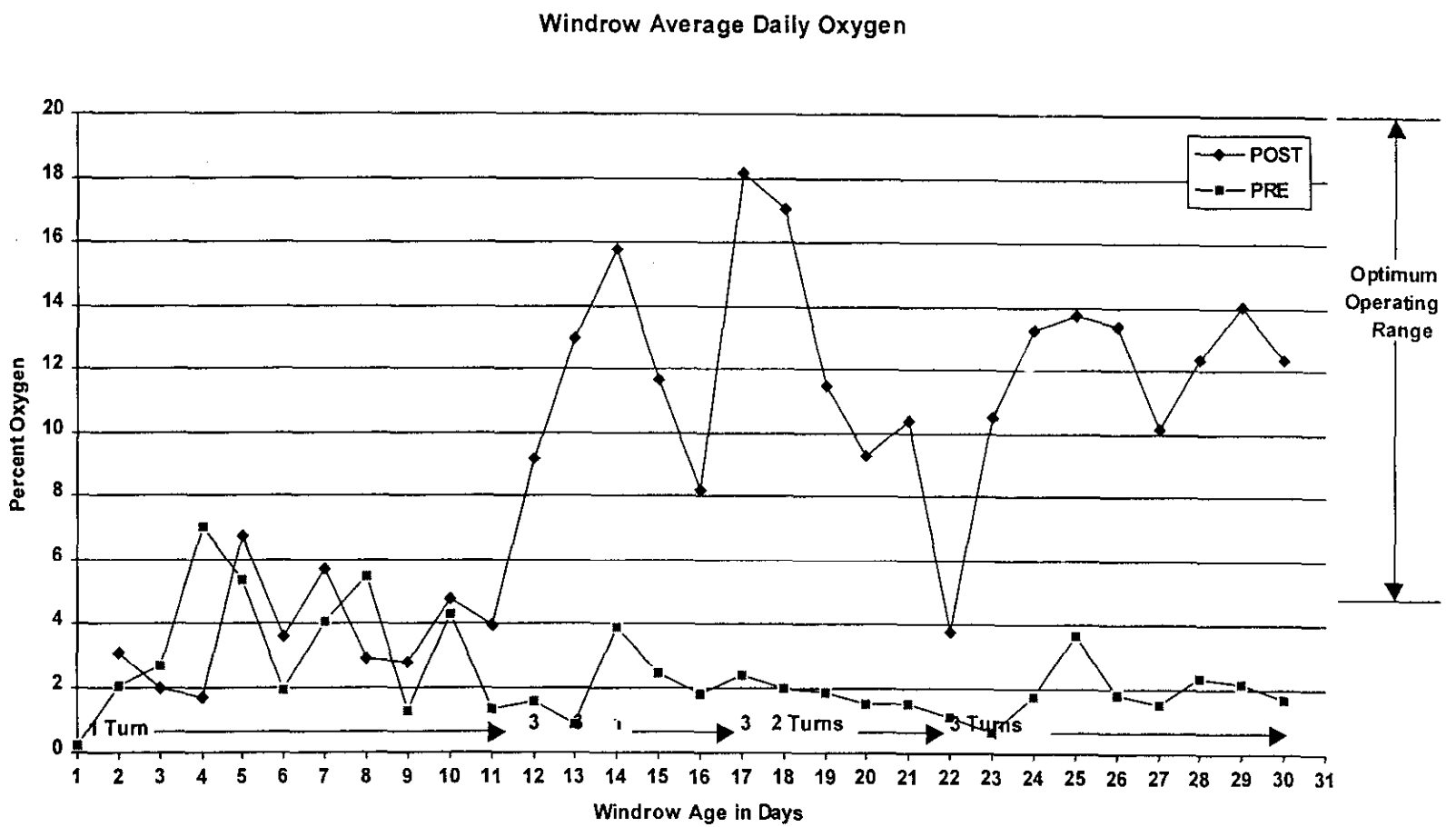
Average Daily Windrow Oxygen Summary Report

Vindrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*PRE-Turn (%)*	*POST-Turn (%)*
MIX6	6/29/97	6/30/97	1	0.38	3.17
		7/1/97	2	0.46	2.33
		7/2/97	3	0.33	1.88
		7/3/97	4	3.83	5.17
		7/4/97	5	1.58	5.33
		7/5/97	6	1.70	1.46
		7/6/97	7	1.79	1.42
		7/7/97	8	1.29	0.71
		7/8/97	9	0.83	0.13
		7/9/97	10	0.17	0.04
		7/10/97	11	1.08	0.25
		7/11/97	12	0.17	0.13
		7/12/97	13	0.00	2.83
		7/13/97	14	0.29	0.88
		7/14/97	15	0.29	1.67
		7/15/97	16	0.79	1.33
		7/16/97	17	0.96	1.38
		7/17/97	18	0.58	2.79
		7/18/97	19	1.71	1.17
		7/19/97	20	1.13	1.04
		7/20/97	21	2.38	1.50
		7/21/97	22	0.46	9.88
		7/22/97	23	1.00	7.71
		7/23/97	24	0.00	6.29
		7/24/97	25	0.00	6.54
		7/25/97	26	0.00	4.75
		7/26/97	27	0.13	5.75
		7/27/97	28	0.08	6.29
		7/28/97	29	0.08	7.00
		7/29/97	30	0.00	9.04

All average Oxygen values are expressed as a percent

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 7B Constructed June 28, 1997



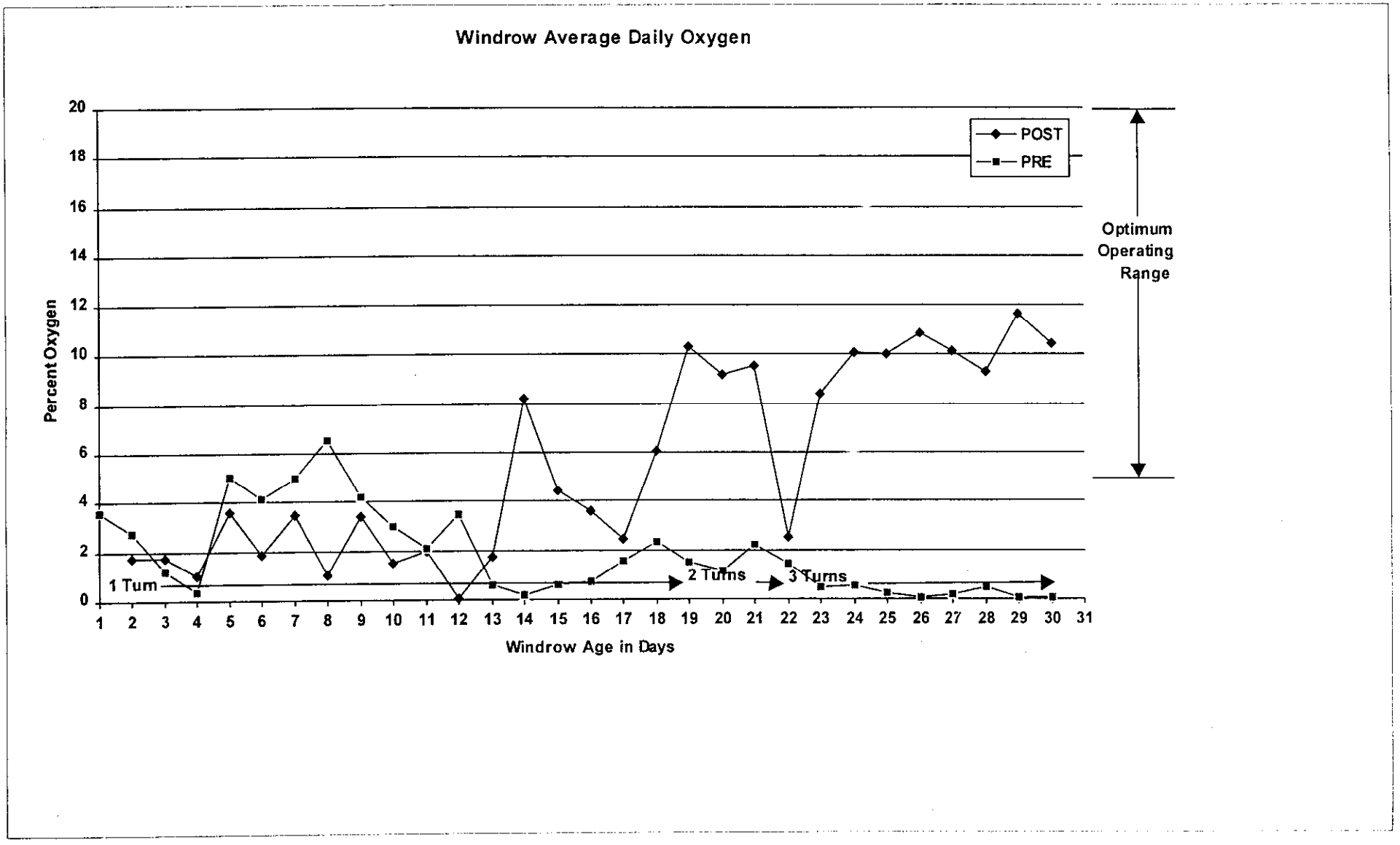
Average Daily Windrow Oxygen Summary Report

'indrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*PRE-Turn (%)*	*POST-Turn (%)*
MIX7B	6/28/97	6/29/97	1	0.21	
		6/30/97	2	2.04	3.08
		7/1/97	3	2.67	1.96
		7/2/97	4	7.00	1.68
		7/3/97	5	5.33	6.71
		7/4/97	6	1.92	3.58
		7/5/97	7	4.08	5.67
		7/6/97	8	5.46	2.88
		7/7/97	9	1.29	2.79
		7/8/97	10	4.29	4.75
		7/9/97	11	1.33	3.92
		7/10/97	12	1.54	9.17
		7/11/97	13	0.88	13.00
		7/12/97	14	3.88	15.75
		7/13/97	15	2.44	11.64
		7/14/97	16	1.80	8.20
		7/15/97	17	2.35	18.16
		7/16/97	18	1.96	17.04
		7/17/97	19	1.83	11.46
		7/18/97	20	1.50	9.29
		7/19/97	21	1.50	10.38
		7/20/97	22	1.13	3.79
		7/21/97	23	0.63	10.50
		7/22/97	24	1.75	13.29
		7/23/97	25	3.63	13.75
		7/24/97	26	1.79	13.42
		7/25/97	27	1.50	10.17
		7/26/97	28	2.29	12.38
		7/27/97	29	2.17	14.04
		7/28/97	30	1.67	12.33

All average Oxygen values are expressed as a percent

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 7C Constructed June 28, 1997



Average Daily Windrow Oxygen Summary Report

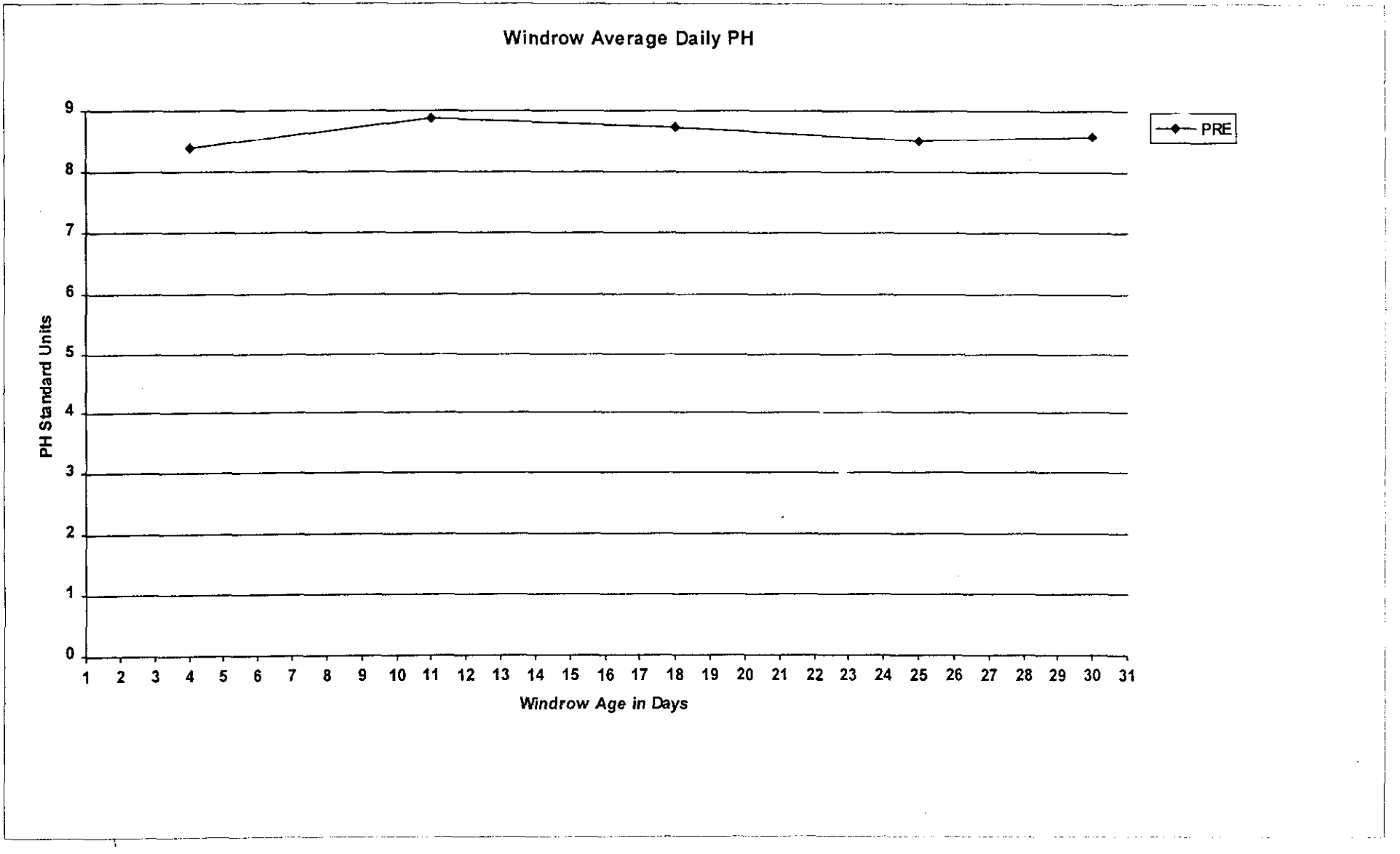
'indrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*PRE-Turn (%)*	*POST-Turn (%)*
MIX7C	6/28/97	6/29/97	1	3.63	
		6/30/97	2	2.75	1.75
		7/1/97	3	1.21	1.75
		7/2/97	4	0.33	1.00
		7/3/97	5	5.04	3.63
		7/4/97	6	4.17	1.88
		7/5/97	7	4.96	3.46
		7/6/97	8	6.54	1.04
		7/7/97	9	4.21	3.42
		7/8/97	10	3.00	1.50
		7/9	11	2.13	2.00
		7/10/97	12	3.50	0.08
		7/11/97	13	0.58	1.75
		7/12/97	14	0.17	8.25
		7/13/97	15	0.63	4.42
		7/14/97	16	0.71	3.63
		7/15/97	17	1.54	2.46
		7/16/97	18	2.33	6.04
		7/17/97	19	1.50	10.33
		7/18/97	20	1.17	9.17
		7/19/97	21	2.25	9.54
		7/20/97	22	1.42	2.54
		7/21/97	23	0.46	8.42
		7/22/97	24	0.54	10.08
		7/23/97	25	0.25	10.04
		7/24/97	26	0.04	10.88
		7/25/97	27	0.17	10.17
		7/26/97	28	0.50	9.29
		7/27/97	29	0.04	11.67
		7/28/97	30	0.08	10.48

All average Oxygen values are expressed as a percent

APPENDIX F
pH DATA AND GRAPHS

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 2 Constructed June 28, 1997



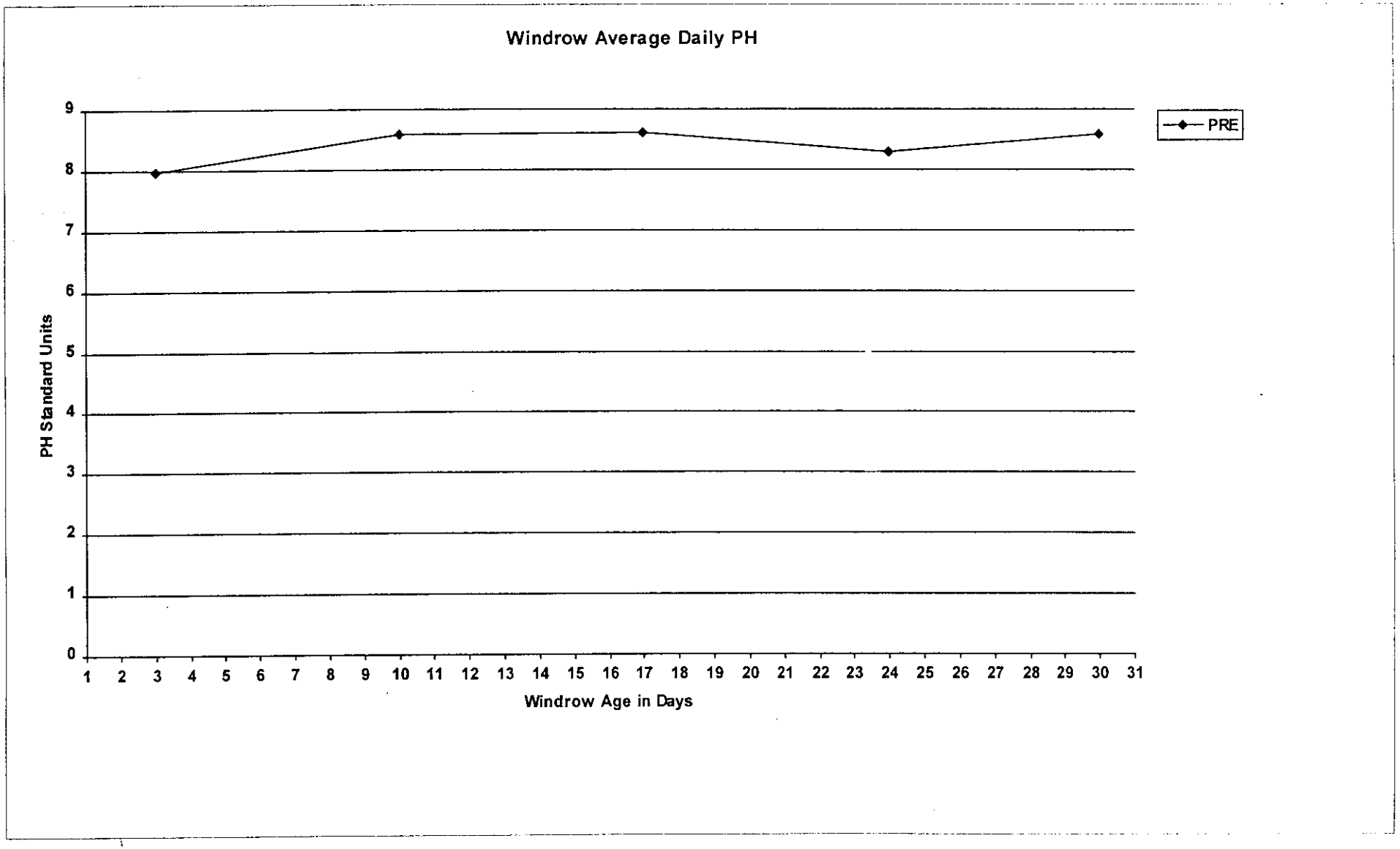
Average Daily Windrow PH Summary Report

'indrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*PRE-Turn (STD Units)*
MIX2	6/28/97	7/2/97	4	8.38
		7/9/97	11	8.88
		7/16/97	18	8.73
		7/23/97	25	8.52
		7/28/97	30	8.57

All average PH values are expressed in standard units

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 3 Constructed June 29, 1997



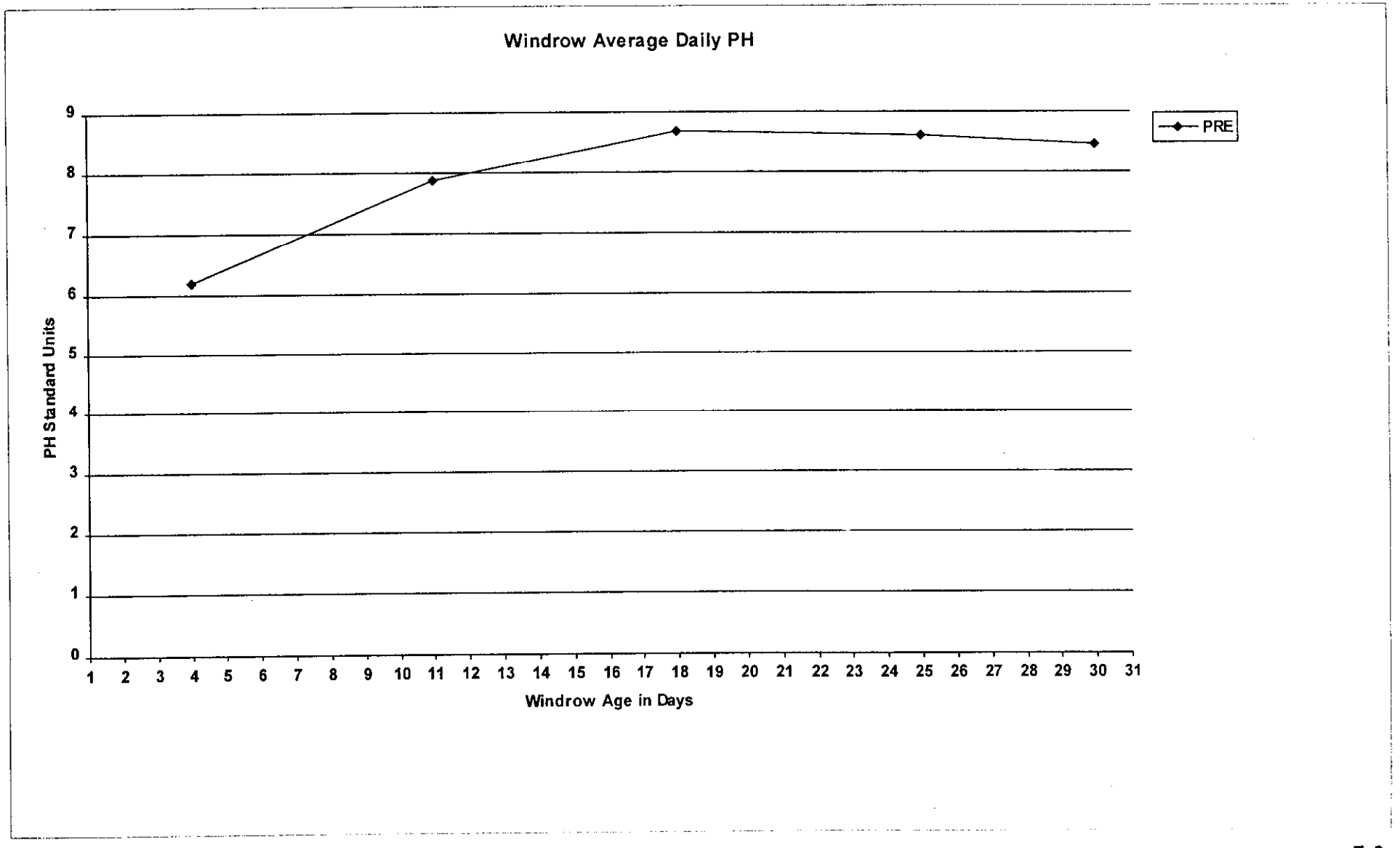
Average Daily Windrow PH Summary Report

Windrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*PRE-Turn (STD Units)*
MIX3	6/29/97	7/2/97	3	7.99
		7/9/97	10	8.57
		7/16/97	17	8.61
		7/23/97	24	8.30
		7/29/97	30	8.58

All average PH values are expressed in standard units

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 4 Constructed June 28, 1997



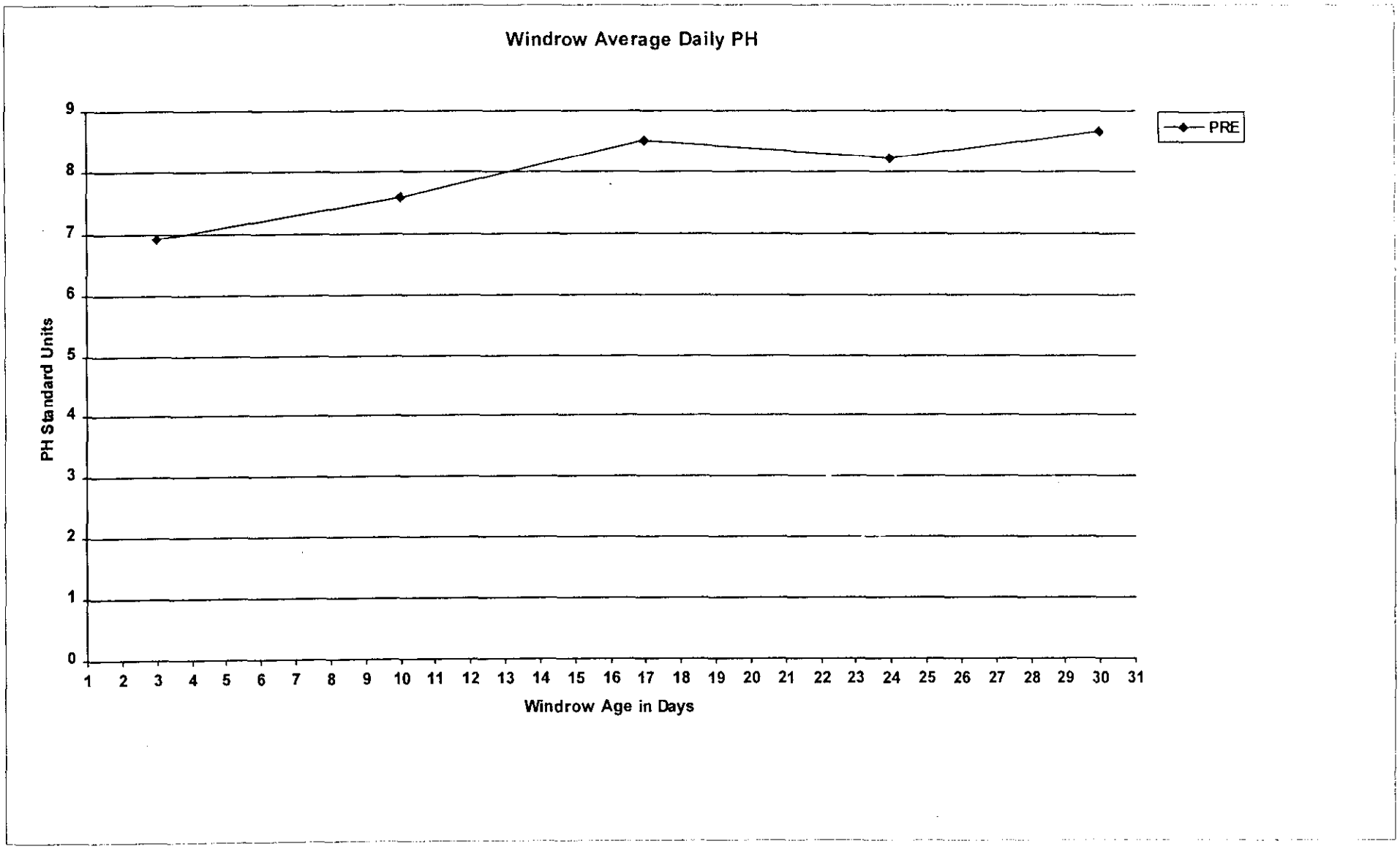
Average Daily Windrow PH Summary Report

'indrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*PRE-Turn (STD Units)*
MIX4	6/28/97	7/2/97	4	6.18
		7/9/97	11	7.88
		7/16/97	18	8.69
		7/23/97	25	8.60
		7/28/97	30	8.45

All average PH values are expressed in standard units

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 5 Constructed June 29, 1997



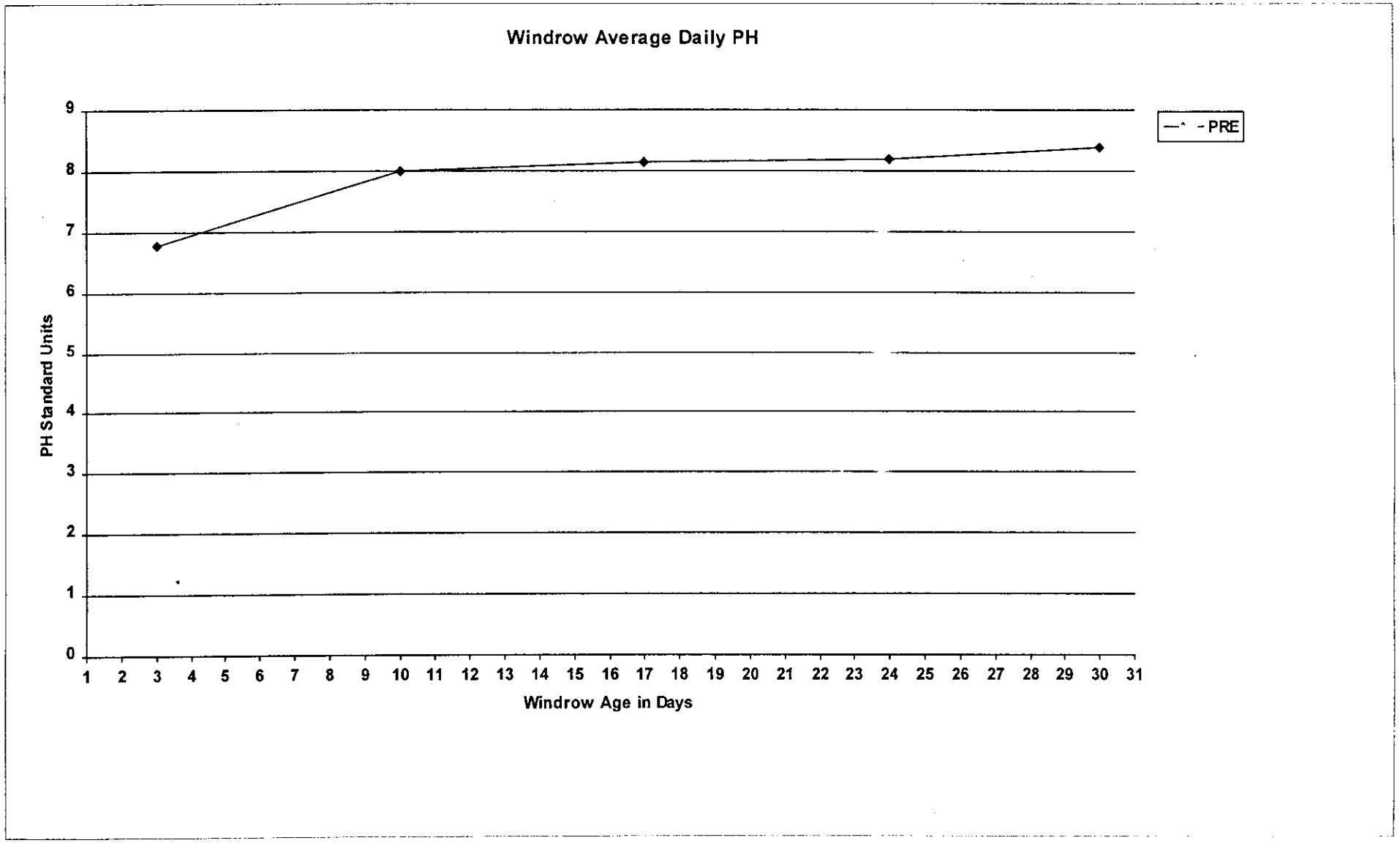
Average Daily Windrow PH Summary Report

Windrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*PRE-Turn (STD Units)*
MIX5	6/29/97	7/2/97	3	6.92
		7/9/97	10	7.58
		7/16/97	17	8.52
		7/23/97	24	8.23
		7/29/97	30	8.65

All average PH values are expressed in standard units

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 6 Constructed June 29, 1997



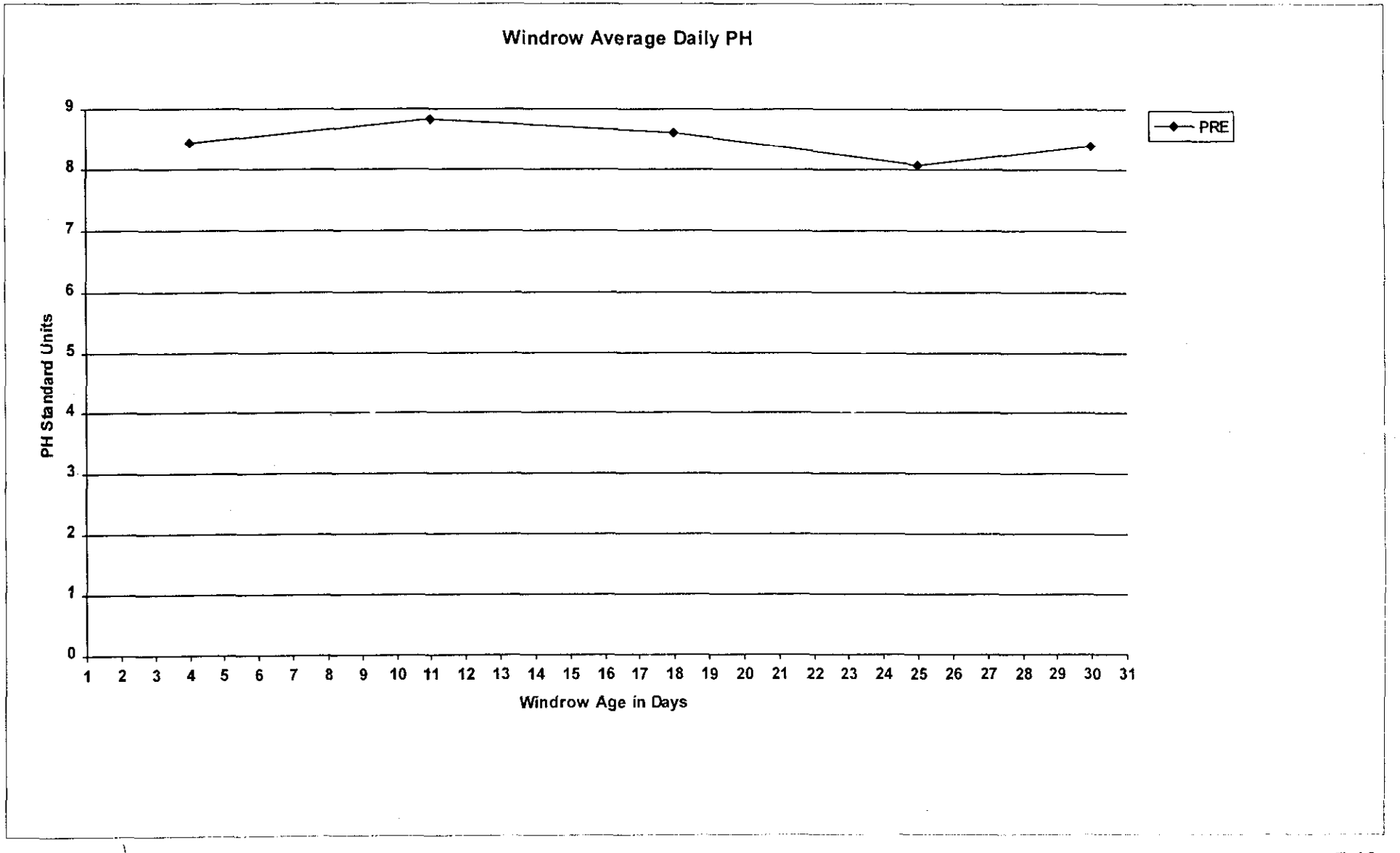
Average Daily Windrow PH Summary Report

Vindrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*PRE-Turn (STD Units)*
MIX6	6/29/97	7/2/97	3	6.78
		7/9/97	10	8.00
		7/16/97	17	8.14
		7/23/97	24	8.19
		7/29/97	30	8.40

All average PH values are expressed in standard units

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 7B Constructed June 28, 1997



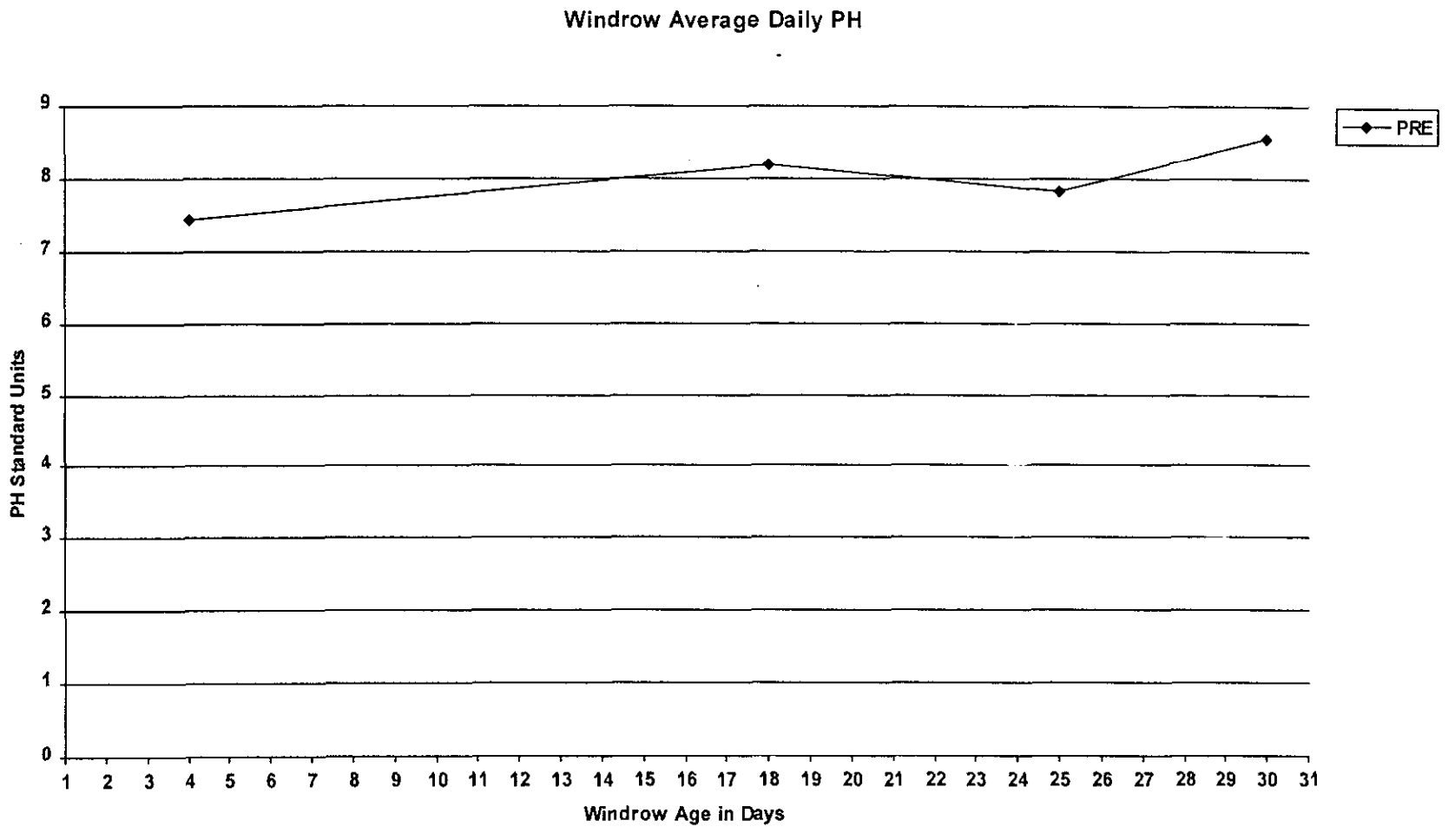
Average Daily Windrow PH Summary Report

Windrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*PRE-Turn (STD Units)*
MIX7B	6/28/97	7/2/97	4	8.44
		7/9/97	11	8.83
		7/16/97	18	8.61
		7/23/97	25	8.07
		7/28/97	30	8.40

All average PH values are expressed in standard units

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 7C Constructed June 28, 1997



Average Daily Windrow PH Summary Report

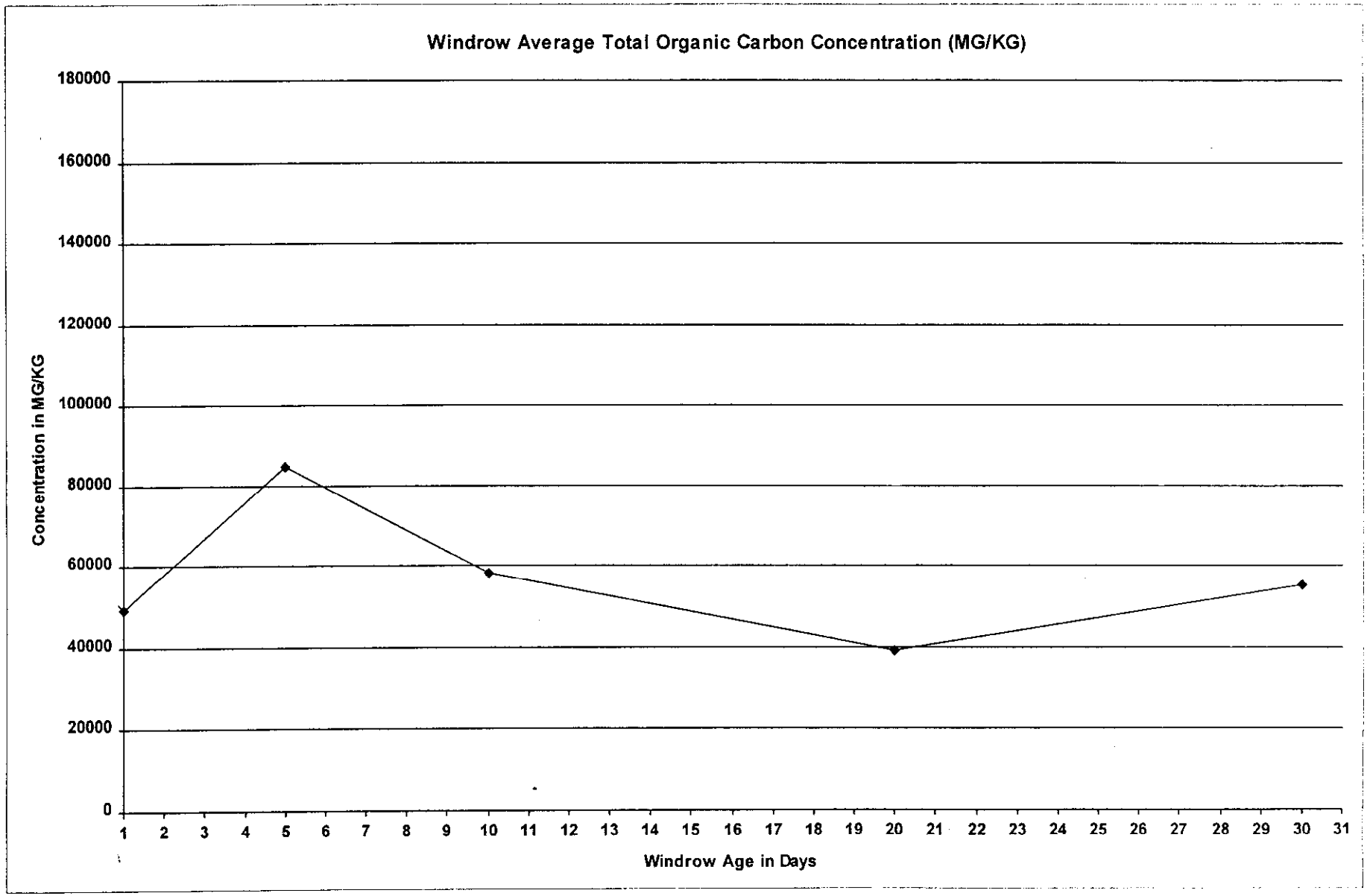
Windrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*PRE-Turn (STD Units)*
MIX7C	6/28/97	7/2/97	4	7.43
		7/16/97	18	8.19
		7/23/97	25	7.82
		7/28/97	30	8.55

All average PH values are expressed in standard units

APPENDIX G
TOC/TKN DATA AND GRAPHS

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 2 Constructed June 28, 1997



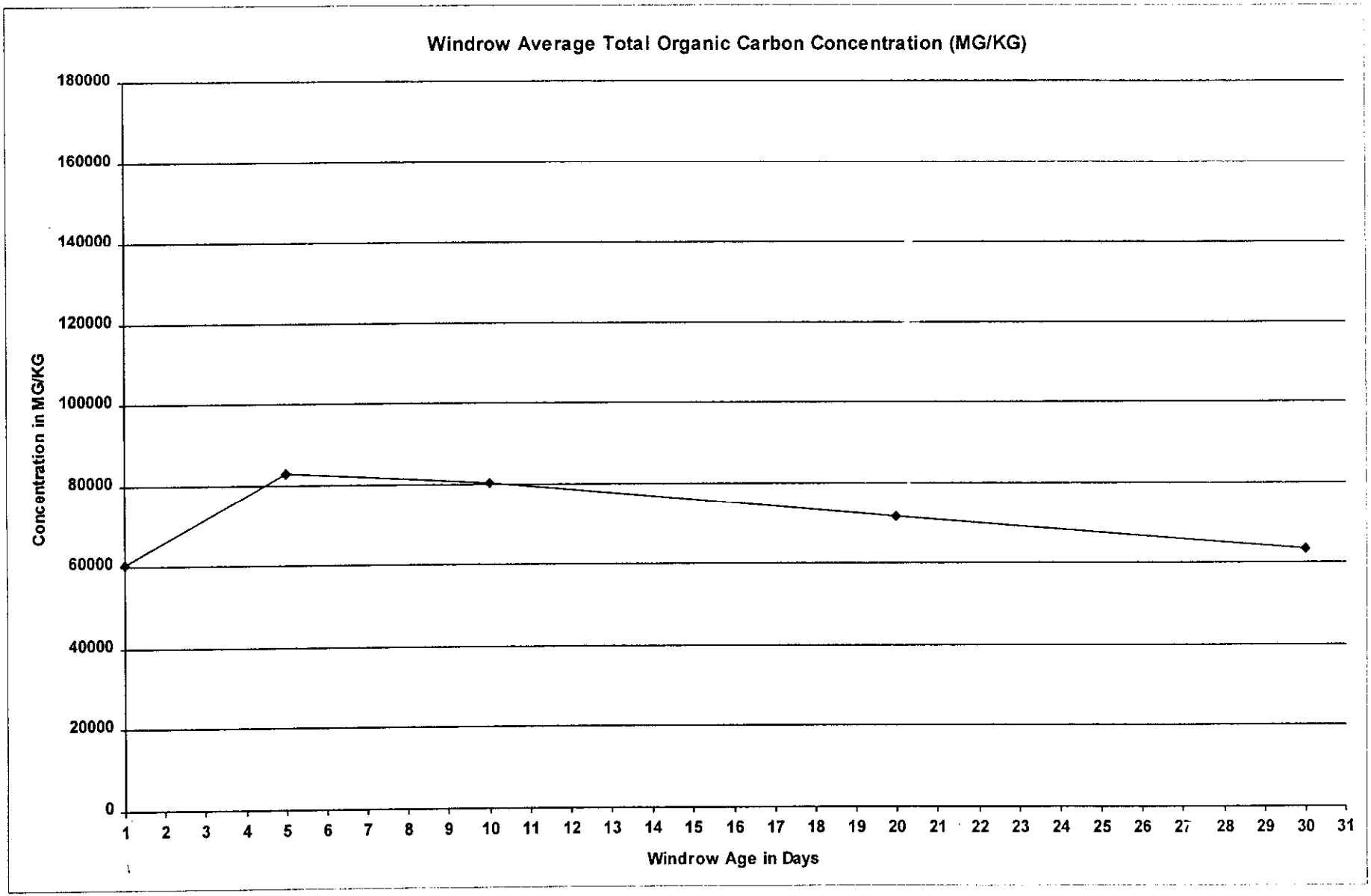
Average Daily Windrow TOC Summary Report

Windrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*Avg. Concentration (MG/KG)*
MIX2	6/28/97	6/28/97	0	59167
		6/29/97	1	49300
		7/3/97	5	84760
		7/8/97	10	58367
		7/18/97	20	39242
		7/28/97	30	55292

All average TOC values are expressed in milligrams per kilogram

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 3 Constructed June 29, 1997



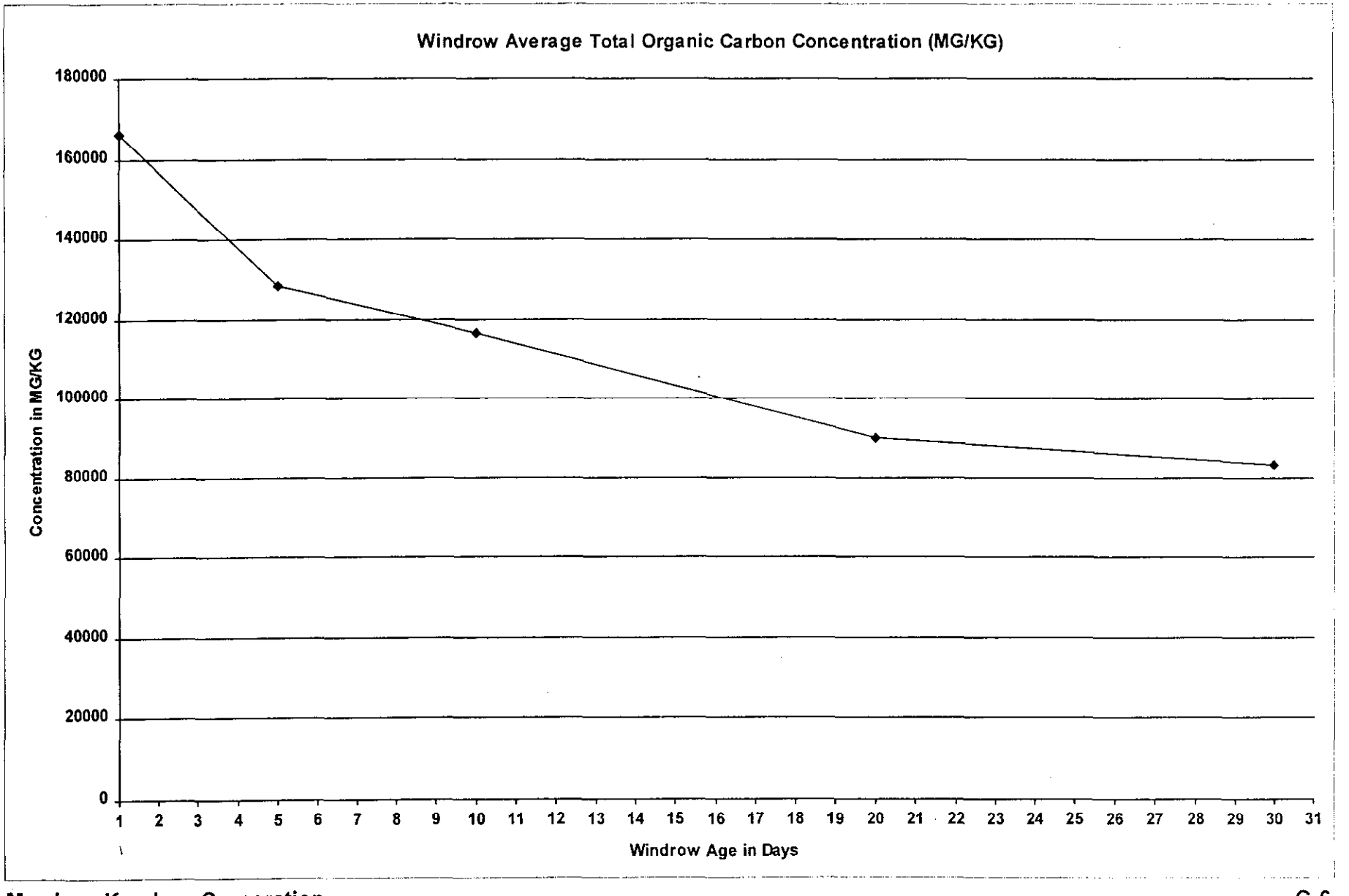
Average Daily Windrow TOC Summary Report

Windrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*Avg. Concentration (MG/KG)*
MIX3	6/29/97	6/30/97	1	60366
		7/4/97	5	82942
		7/9/97	10	80450
		7/19/97	20	71567
		7/29/97	30	63333

All average TOC values are expressed in milligrams per kilogram

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 4 Constructed June 28, 1997



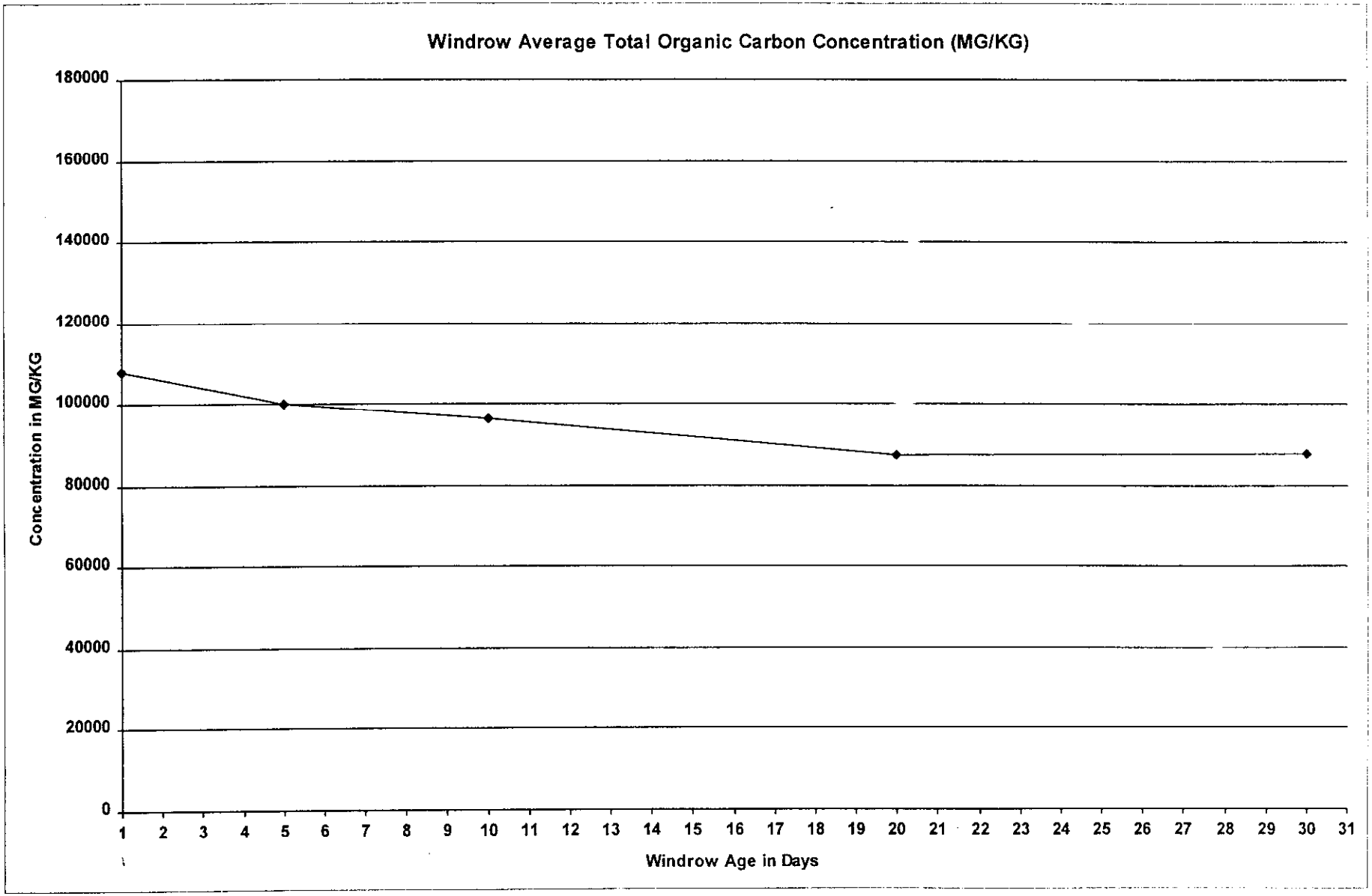
Average Daily Windrow TOC Summary Report

ndrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*Avg. Concentration (MG/KG)*
MIX4	6/28/97	6/29/97	1	166117
		7/3/97	5	128617
		7/8/97	10	116625
		7/18/97	20	89950
		7/28/97	30	83325

All average TOC values are expressed in milligrams per kilogram

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 5 Constructed June 29, 1997



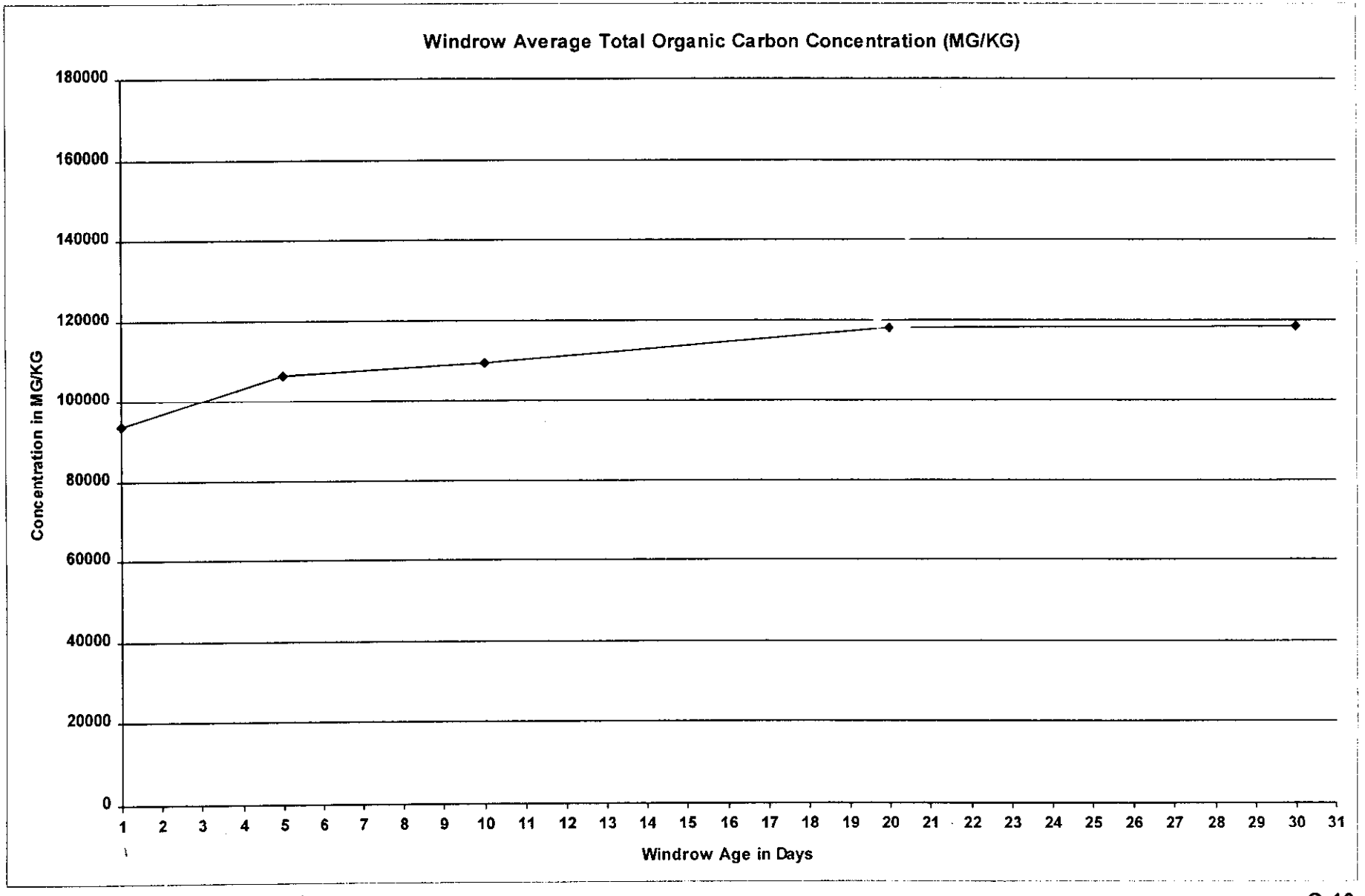
Average Daily Windrow TOC Summary Report

'indrow Number	Construction Date	Date Monitored	Age (Days)	Avg. Concentration (MG/KG)
MIX5	6/29/97	6/30/97	1	107908
		7/4/97	5	100125
		7/9/97	10	96358
		7/19/97	20	87225
		7/29/97	30	87908

All average TOC values are expressed in milligrams per kilogram

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 6 Constructed June 29, 1997



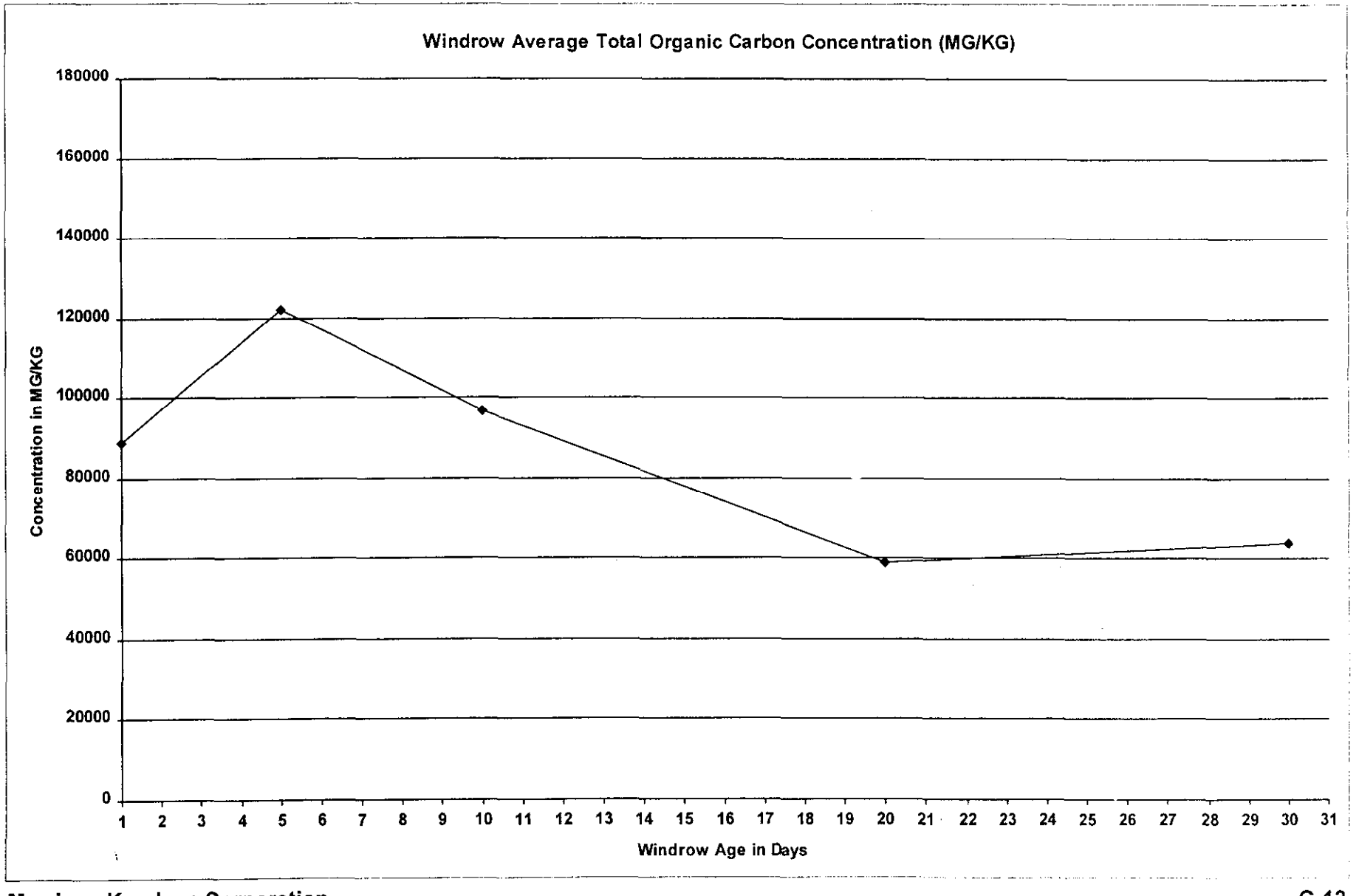
Average Daily Windrow TOC Summary Report

'indrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*Avg. Concentration (MG/KG)*
MIX6	6/29/97	6/30/97	1	93725
		7/4/97	5	106600
		7/9/97	10	109308
		7/19/97	20	117929
		7/29/97	30	118471

All average TOC values are expressed in milligrams per kilogram

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 7B Constructed June 28, 1997



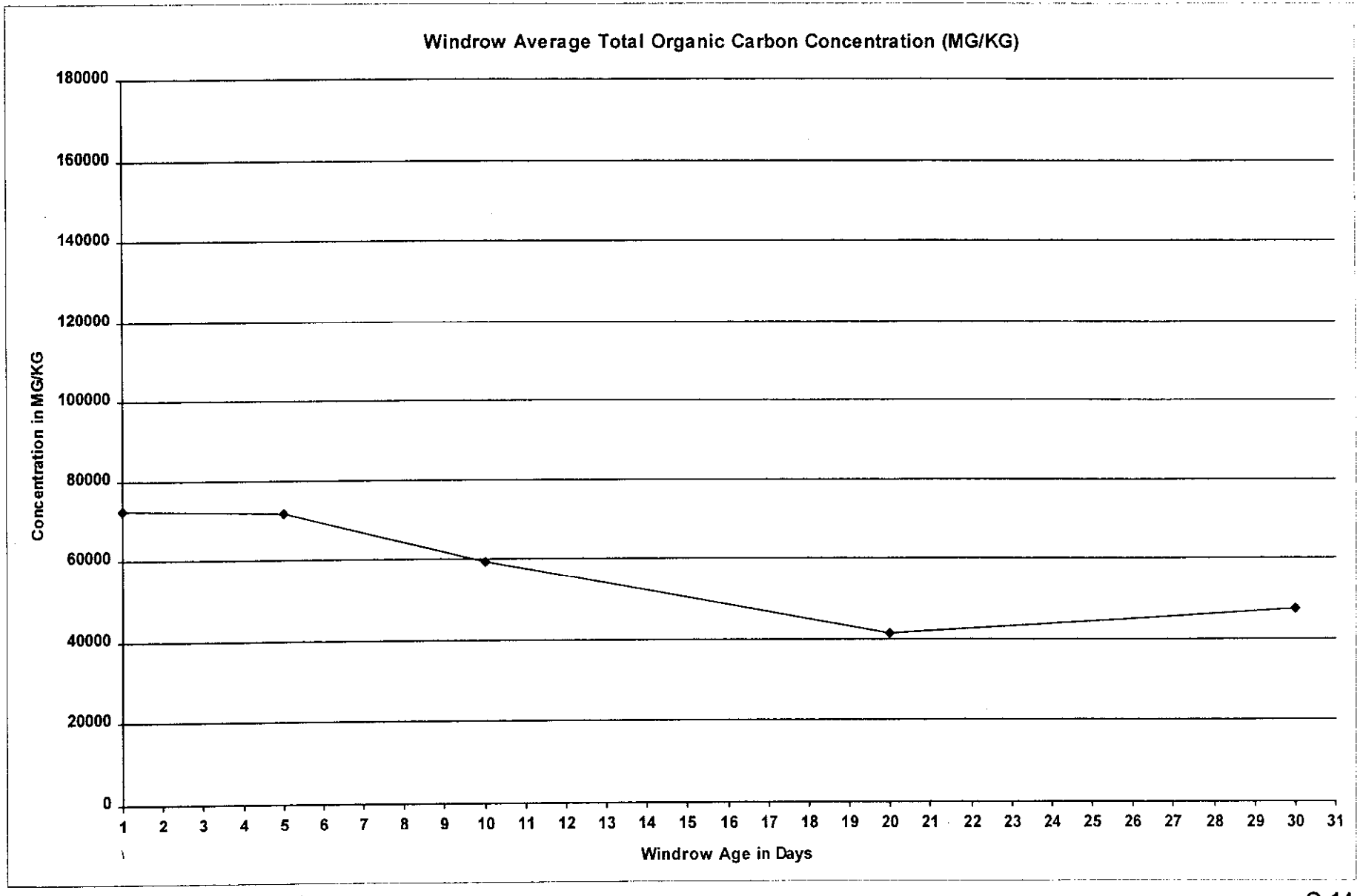
Average Daily Windrow TOC Summary Report

ndrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*Avg. Concentration (MG/KG)*
MIX7B	6/28/97	6/29/97	1	88717
		7/3/97	5	122167
		7/8/97	10	96833
		7/18/97	20	59133
		7/28/97	30	63933

All average TOC values are expressed in milligrams per kilogram

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 7C Constructed June 28, 1997



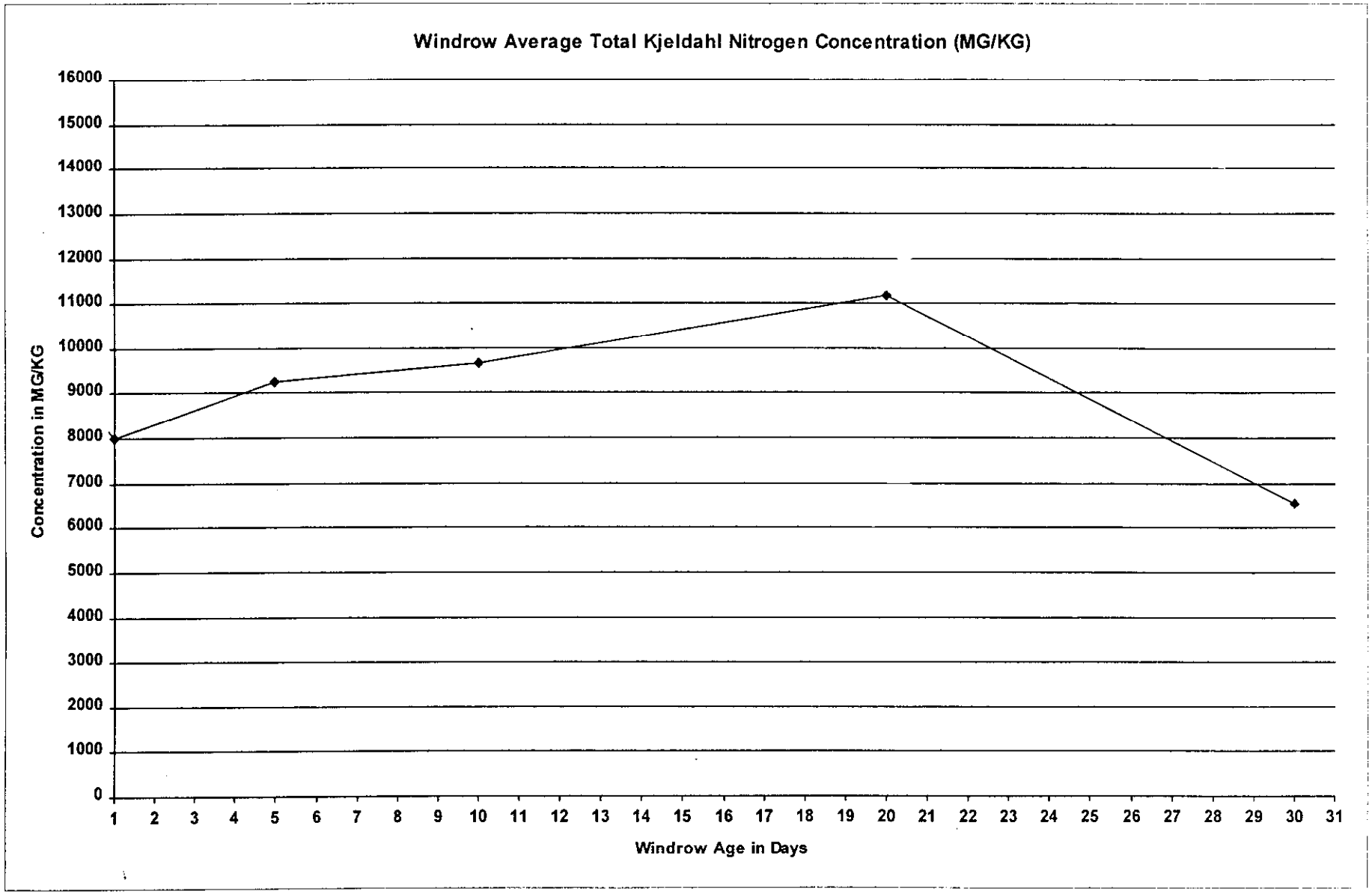
Average Daily Windrow TOC Summary Report

Windrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*Avg. Concentration (MG/KG)*
MIX7C	6/28/97	6/29/97	1	72542
		7/3/97	5	71675
		7/8/97	10	59267
		7/18/97	20	41275
		7/28/97	30	47500

All average TOC values are expressed in milligrams per kilogram

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 2 Constructed June 28, 1997



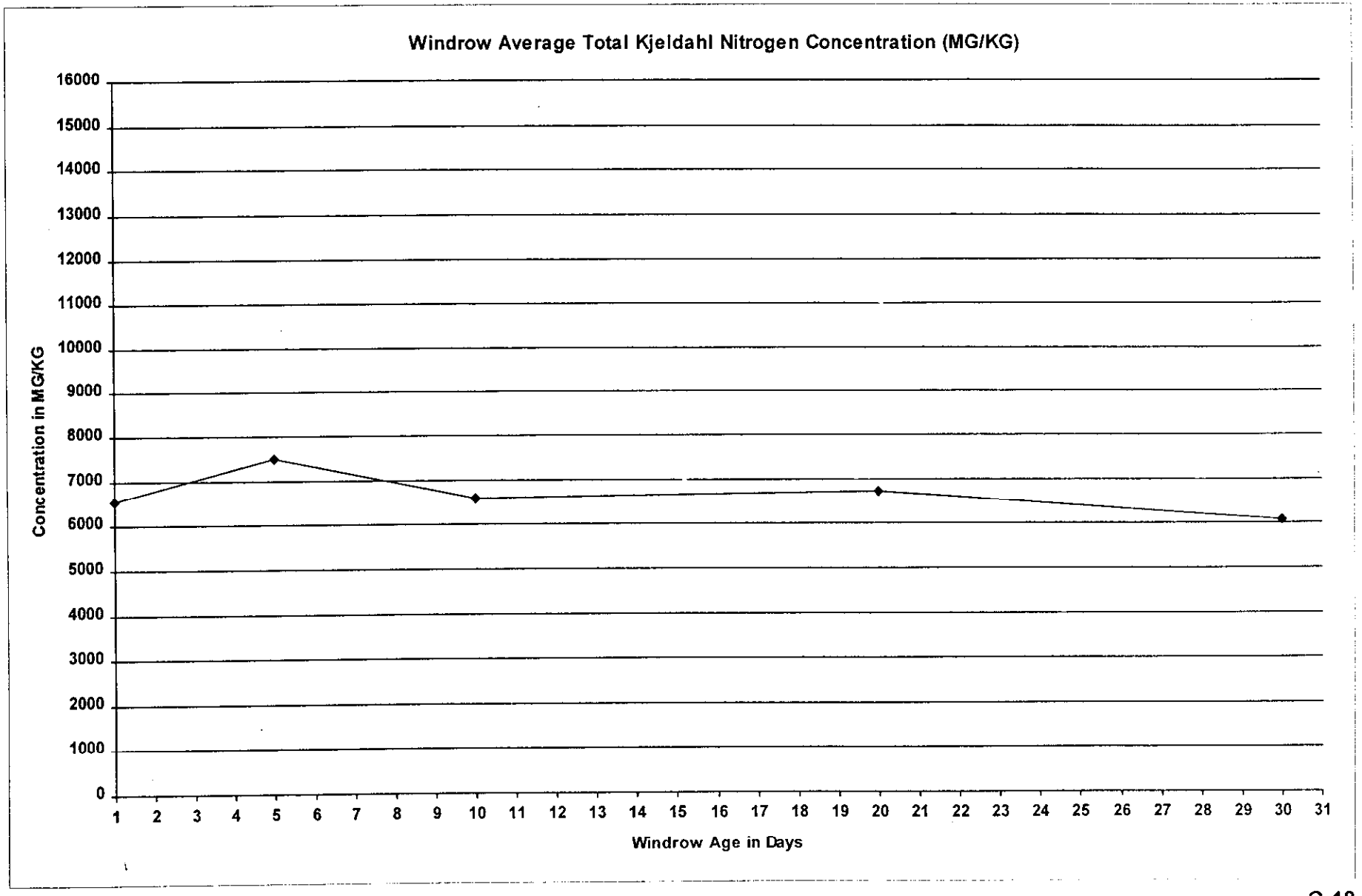
Average Daily Windrow TKN Summary Report

Windrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*Avg. Concentration (MG/KG)*
MIX2	6/28/97	6/28/97	0	9060
		6/29/97	1	8012
		7/3/97	5	9233
		7/8/97	10	9639
		7/18/97	20	11182
		7/28/97	30	6558

All average TKN values are expressed in milligrams per kilogram

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 3 Constructed June 29, 1997



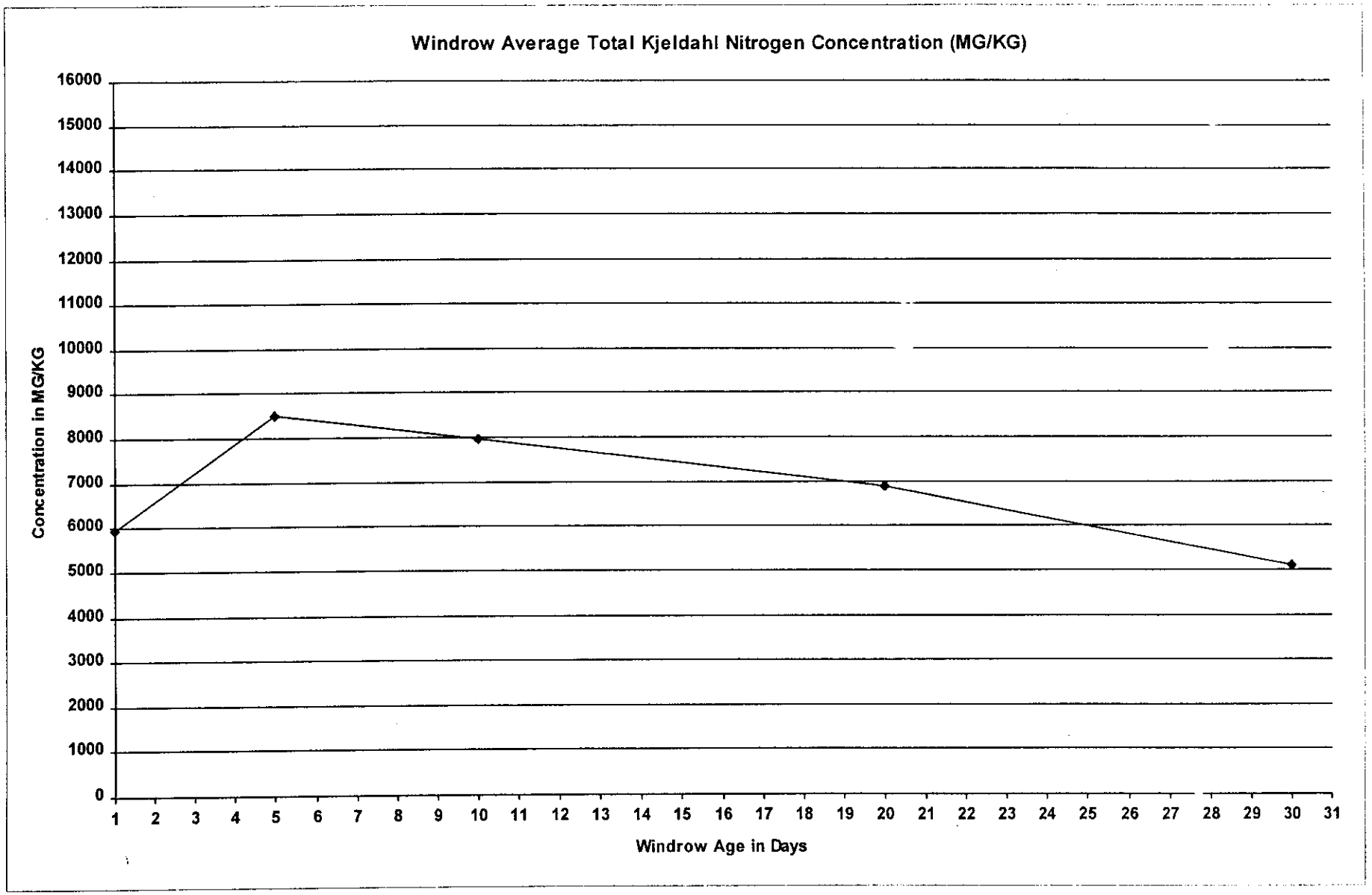
Average Daily Windrow TKN Summary Report

indrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*Avg. Concentration (MG/KG)*
MIX3	6/29/97	6/30/97	1	6532
		7/4/97	5	7497
		7/9/97	10	6584
		7/19/97	20	6729
		7/29/97	30	6090

All average TKN values are expressed in milligrams per kilogram

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 4 Constructed June 28, 1997



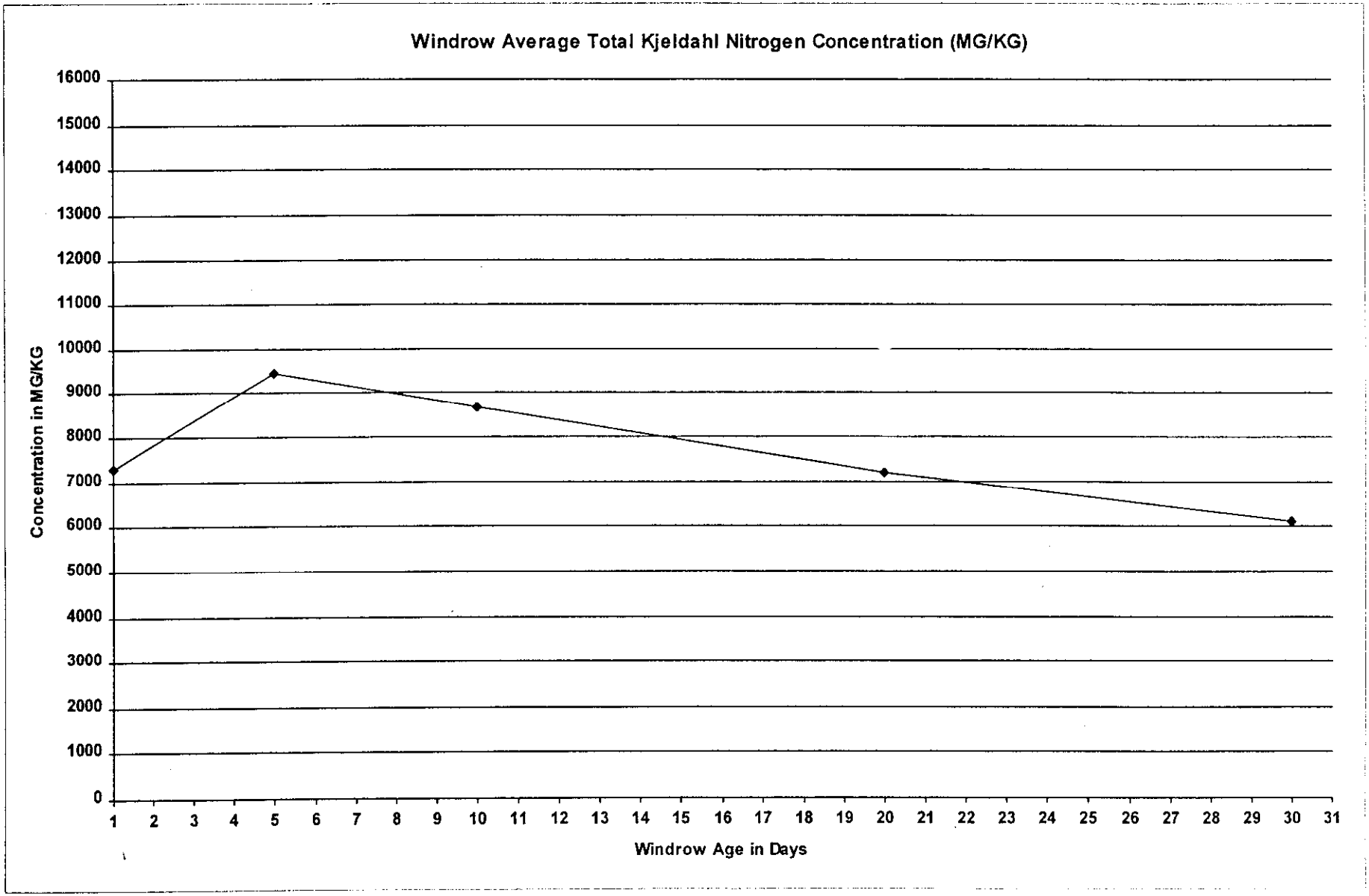
Average Daily Windrow TKN Summary Report

indrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*Avg. Concentration (MG/KG)*
MIX4	6/28/97	6/29/97	1	5952
		7/3/97	5	8505
		7/8/97	10	7955
		7/18/97	20	6901
		7/28/97	30	5093

All average TKN values are expressed in milligrams per kilogram

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 5 Constructed June 29, 1997



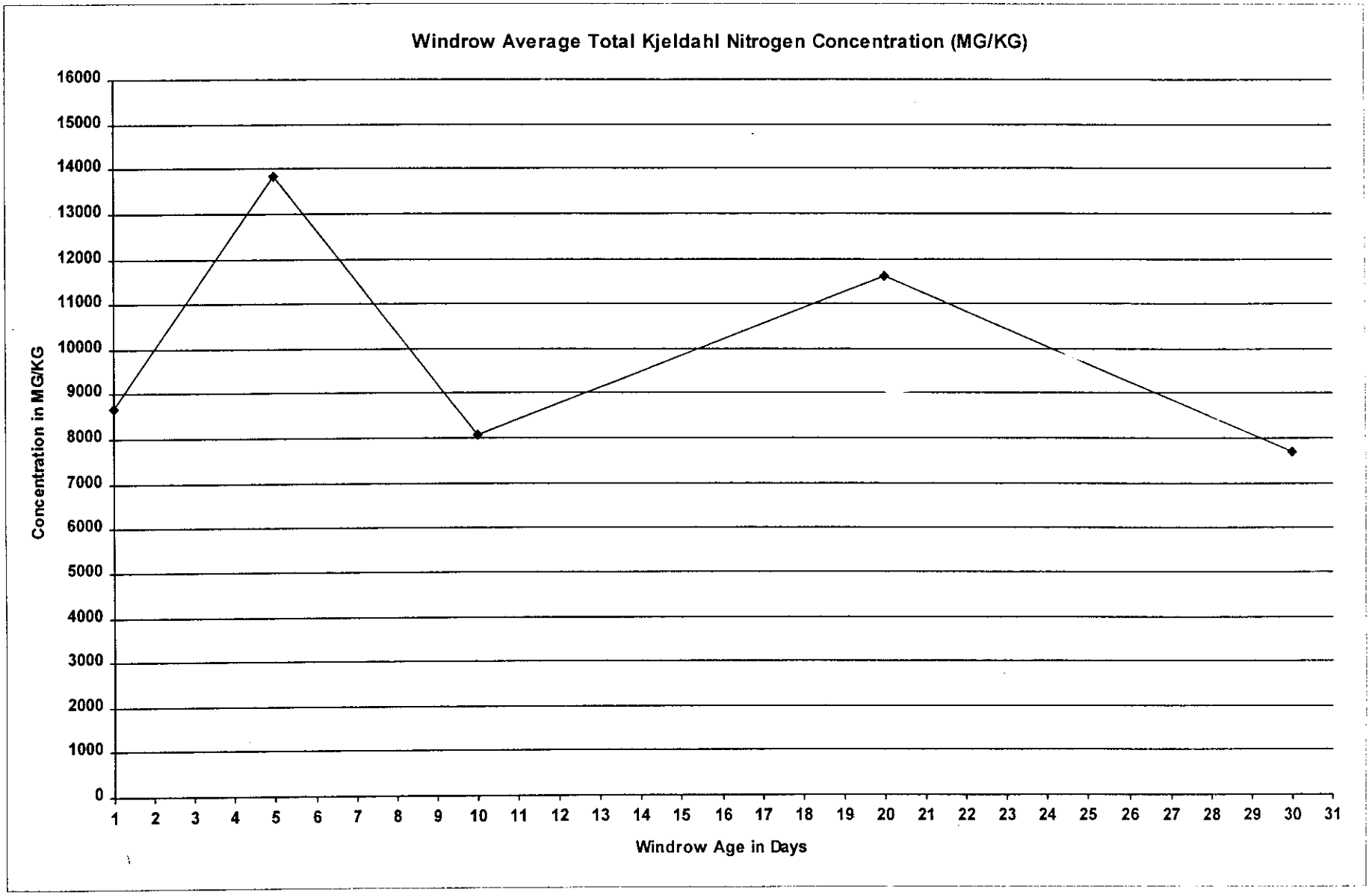
Average Daily Windrow TKN Summary Report

indrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*Avg. Concentration (MG/KG)*
MIX5	6/29/97	6/30/97	1	7300
		7/4/97	5	9467
		7/9/97	10	8692
		7/19/97	20	7203
		7/29/97	30	6105

All average TKN values are expressed in milligrams per kilogram

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 6 Constructed June 29, 1997



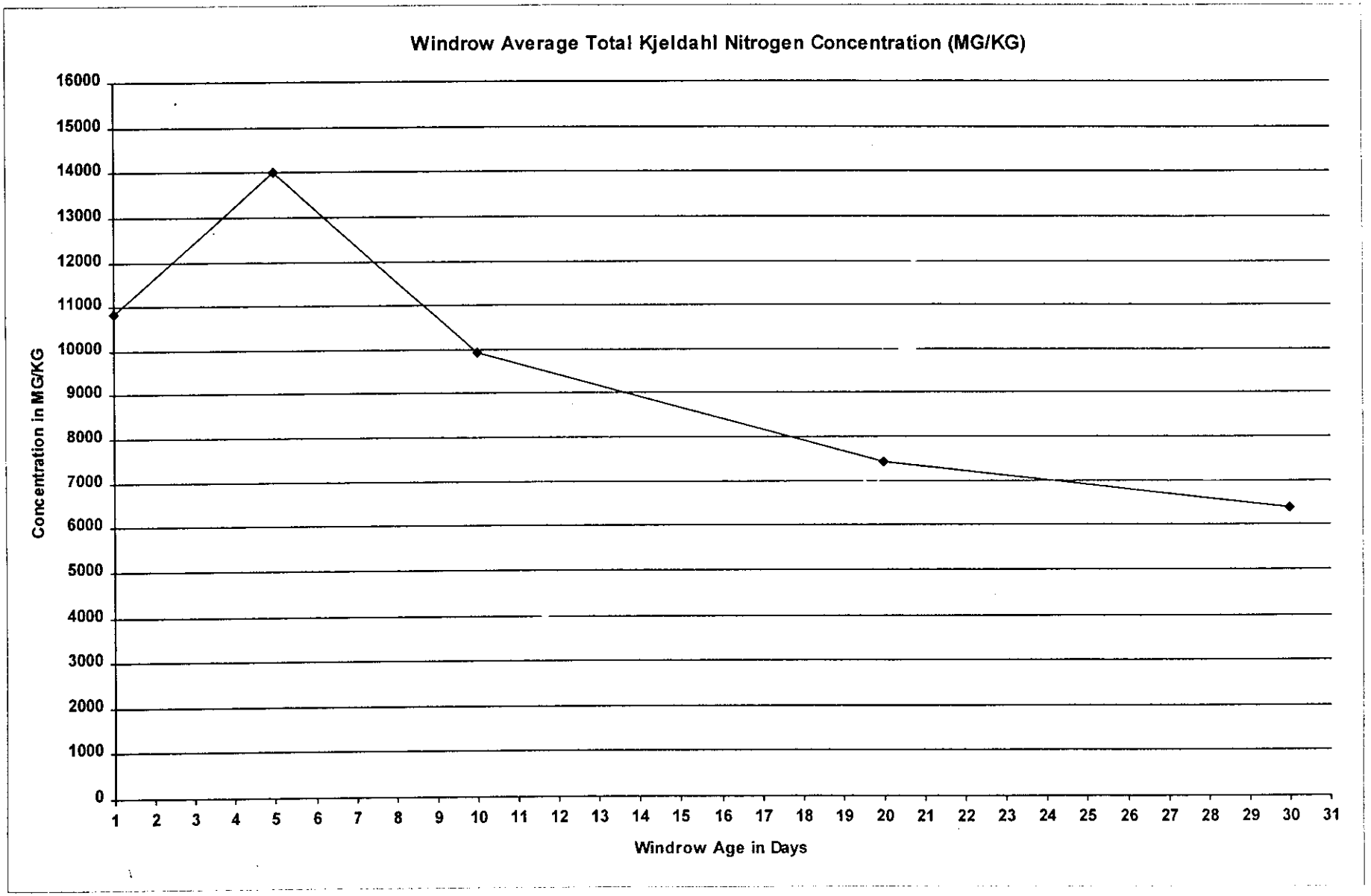
Average Daily Windrow TKN Summary Report

indrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*Avg. Concentration (MG/KG)*
MIX6	6/29/97	6/30/97	1	8687
		7/4/97	5	13841
		7/9/97	10	8078
		7/19/97	20	11609
		7/29/97	30	7693

All average TKN values are expressed in milligrams per kilogram

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 7B Constructed June 28, 1997



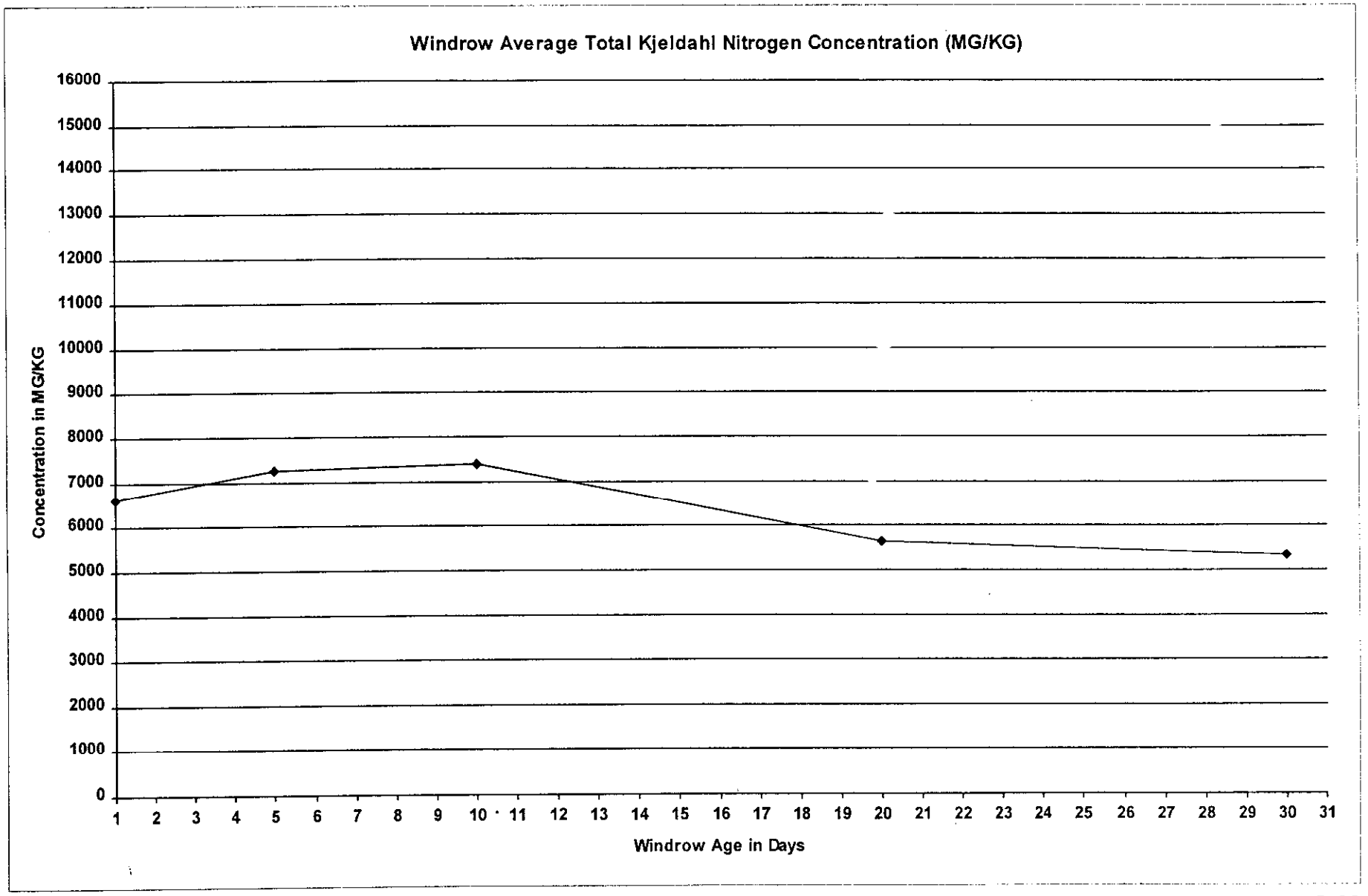
Average Daily Windrow TKN Summary Report

'indrow Number	*Construction Date*	*Date Monitored*	*Age (Days)*	*Avg. Concentration (MG/KG)*
MIX7B	6/28/97	6/29/97	1	10850
		7/3/97	5	13993
		7/8/97	10	9937
		7/18/97	20	7436
		7/28/97	30	6393

All average TKN values are expressed in milligrams per kilogram

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration

Compost Recipe Mix 7C Constructed June 28, 1997



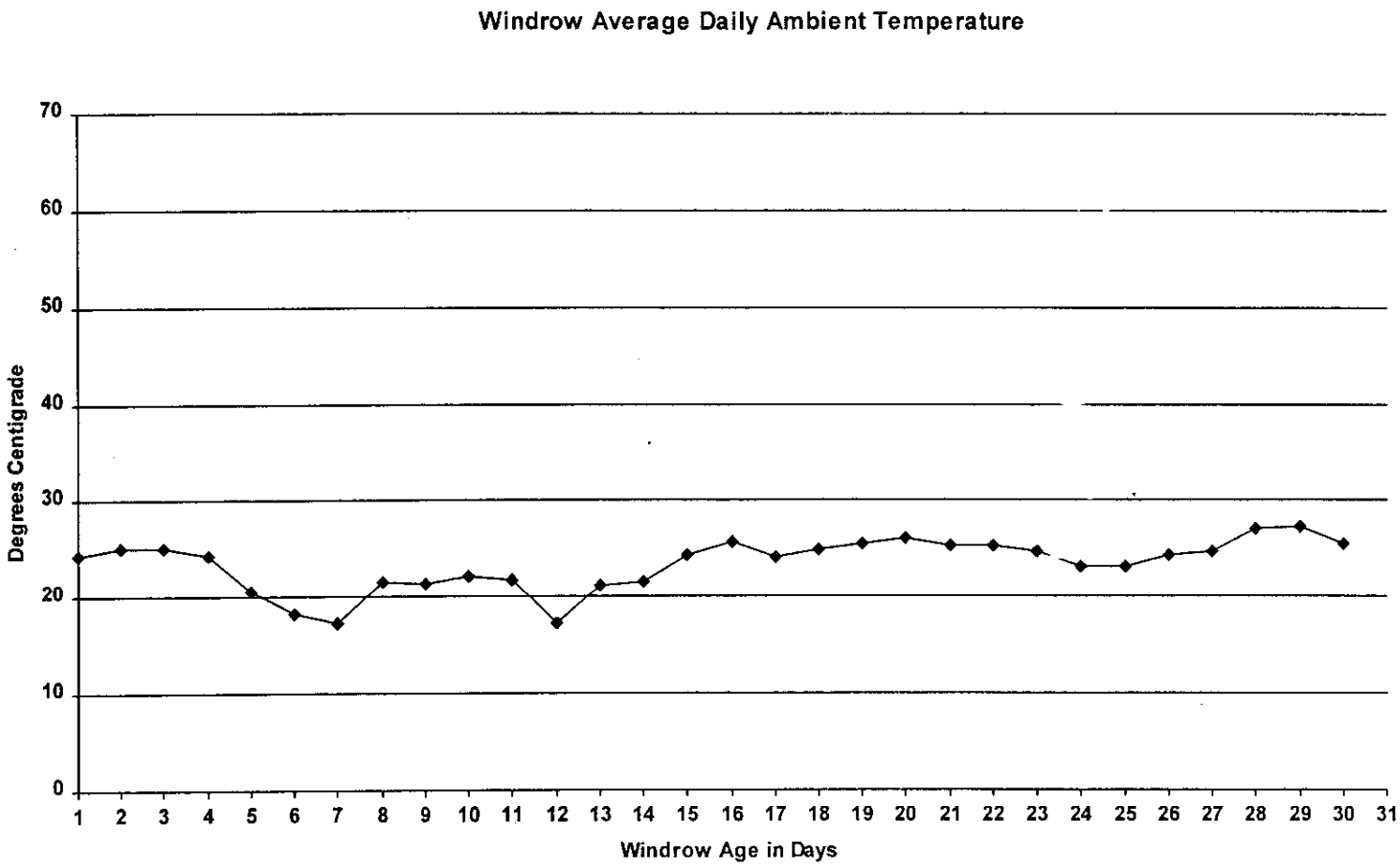
Average Daily Windrow TKN Summary Report

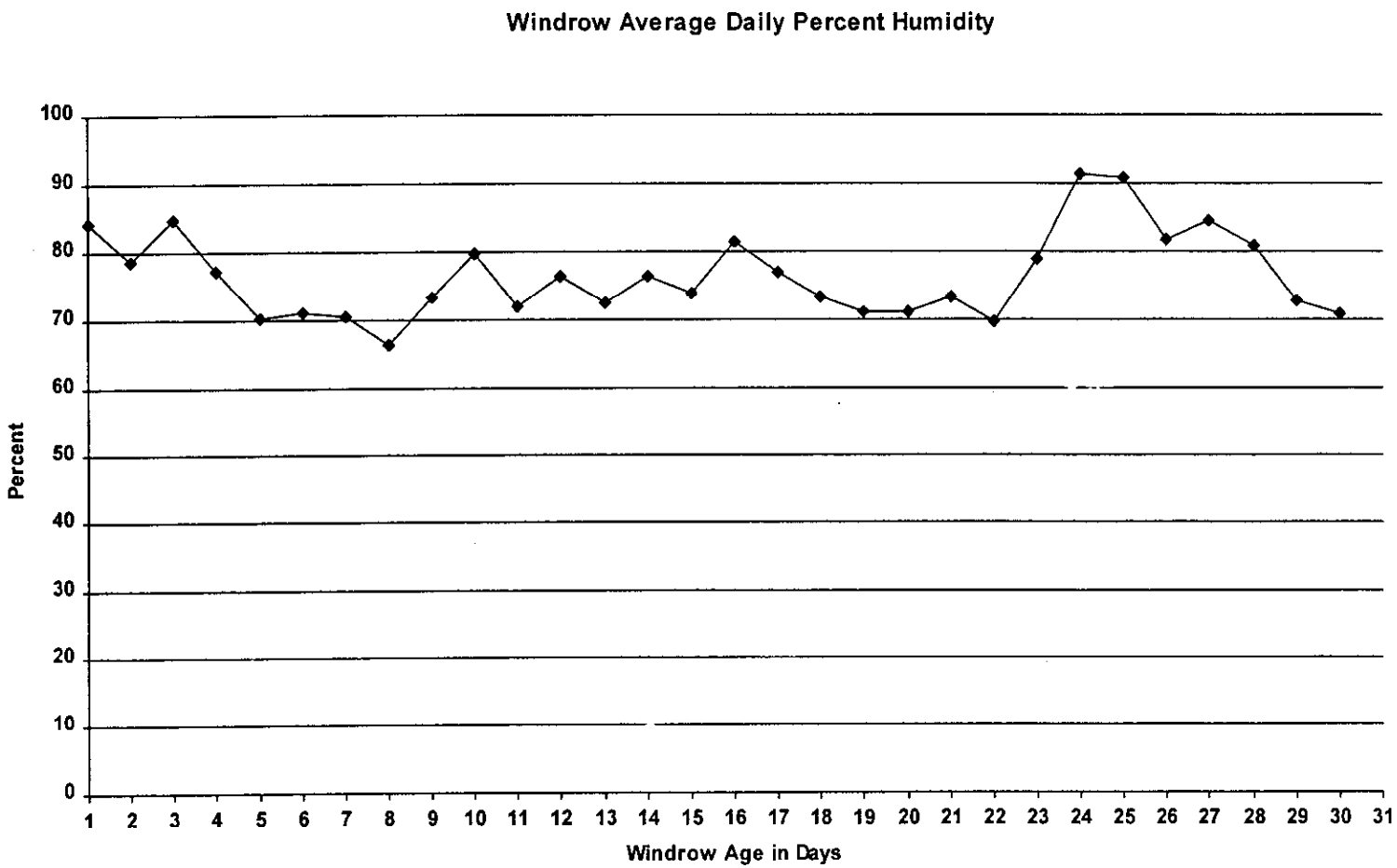
Windrow Number	Construction Date	Date Monitored	Age (Days)	Avg. Concentration (MG/KG)
MIX7C	6/28/97	6/29/97	1	6611
		7/3/97	5	7244
		7/8/97	10	7406
		7/18/97	20	5628
		7/28/97	30	5349

All average TKN values are expressed in milligrams per kilogram

APPENDIX H
AMBIENT TEMPERATURE AND RELATIVE HUMIDITY

NSWC Crane BioFacility Pilot Scale Clean Soil Demonstration




Windrow Average Daily Percent Humidity
Percent
100
90
80
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Windrow Age in Days