WOLF CREEK COMPOST FACILITY OPERATION AND MAINTENANCE MANUAL

SECOND EDITION

REDWOOD NATIONAL PARK

RESEARCH AND DEVELOPMENT

SACKLIN, JOHN

TECHNICAL REPORT 4

SEPTEMBER 1982

- WOLF CREEK COMPOST FACILITY -

Operation and Maintenance Manual

Second Edition

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National Park Service
Redwood National Park
Arcata, California
September 1982

- EMERGENCY PROCEDURES -

In the event of either an effluent spill in excess of 20 gallons outside the mixing pad or an effluent spill of any quantity into a stream, the operator shall immediately notify the Chief of Maintenance. The Chief of Maintenance will contact the Superintendent; Chief, Technical Services Division; Regional Water Quality Control Board; and the Humboldt County Health Department. In the event of any spill into a stream, all downstream water users will be notified.

Contact	Telephone Number (Area Code 707)
Chief of Maintenance	464-6101
Superintendent	464-6101
Chief, Technical Services Division	822-7611
Regional Water Quality Control Board	576-2220
Humboldt County Health Department	445-7613

Creek	Contact	Telephone Number (Area Code 707)
Prairie	Humboldt County Fish Hatchery	488-2253
	Robert Davison	488-3732
	Prairie Creek Motel:	
	Leslie Dobson	488-3841
	Arcata Redwood Company	488-3351
	Paul Leazer	488-2273
Redwood	Orick Community Services District:	
	Secretary:	
	Thelma Hufford	488-5903
	Directors:	
	Joseph Hufford	488-2602
	Joe Romanini	488-3715
	Gloria Zuber	488-2524
	Sam Lane	488-5325

- WOLF CREEK COMPOST FACILITY -

Operation and Maintenance Manual

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- PREFACE -

This operations manual was prepared pursuant to the requirements of the California Regional Water Quality Control Board Order Number 81-25, Discharge Specification Number 6. The manual is intended to be a guide to help operate the Wolf Creek Compost System. The first edition of this manual was prepared in June 1981, prior to the initiation of composting; this edition has been revised to reflect a compost system which became operational in May 1982.

- ACKNOWLEDGEMENTS -

Preparation of this manual relied on Patrick Shea, Landscape Architect; Dennis Hill, former Facility Manager, now at Cuyahoga Valley National Recreation Area; L. Lee Purkerson, Chief Technical Services Division; Joe Lusa, Chief of Maintenance; Johnny Bob Nelson, Systems Operations Foreman; and especially Jim Patterson, Agronomist, National Capital Region, for his assistance throughout the project and his numerous articles on composting. I also thank Tom Marquette for graphics and editorial assistance and Ron Knickerbocker, Francie Murphy and Susan Richey for clerical assistance.

I. Introduction

A. Overview

Static-pile composting utilizes aerobic biological processes to decompose organic waste material under controlled conditions to a state in which it can be handled and stored safely and applied to the land without adversely affecting the environment (from Golueke, 1972).

Static-pile composting is similar to a backyard compost pile that is built properly and turned frequently. The key differences are an increase in size of the compost pile to make the operation efficient and retain heat better, and use of a pump to draw air through the pile to maintain aerobic conditions.

Redwood National Park's static-pile composting project is located at Wolf Creek (see map) and treats wastes generated in the National Park from chemical toilets and septic tanks. In time other wastes, such as black water from holding tanks, sludge from sewage treatment plants, and vehicle dumping stations, may be used for composting. Compost is utilized as a soil amendment during the park's watershed rehabilitation program or in landscape spreading associated with park developments. Land application sites will be approved by the Regional Water Quality Control Board Executive Officer prior to use.

Redwood National Park's static-pile composting project is modeled after the Chesapeake and Ohio Canal National Historical Park composting system. The C. & O. Canal composting project has been underway since 1976 to treat waste from chemical toilets. Details regarding the C. & O. system are presented in Patterson, 1979b (see Appendix B).

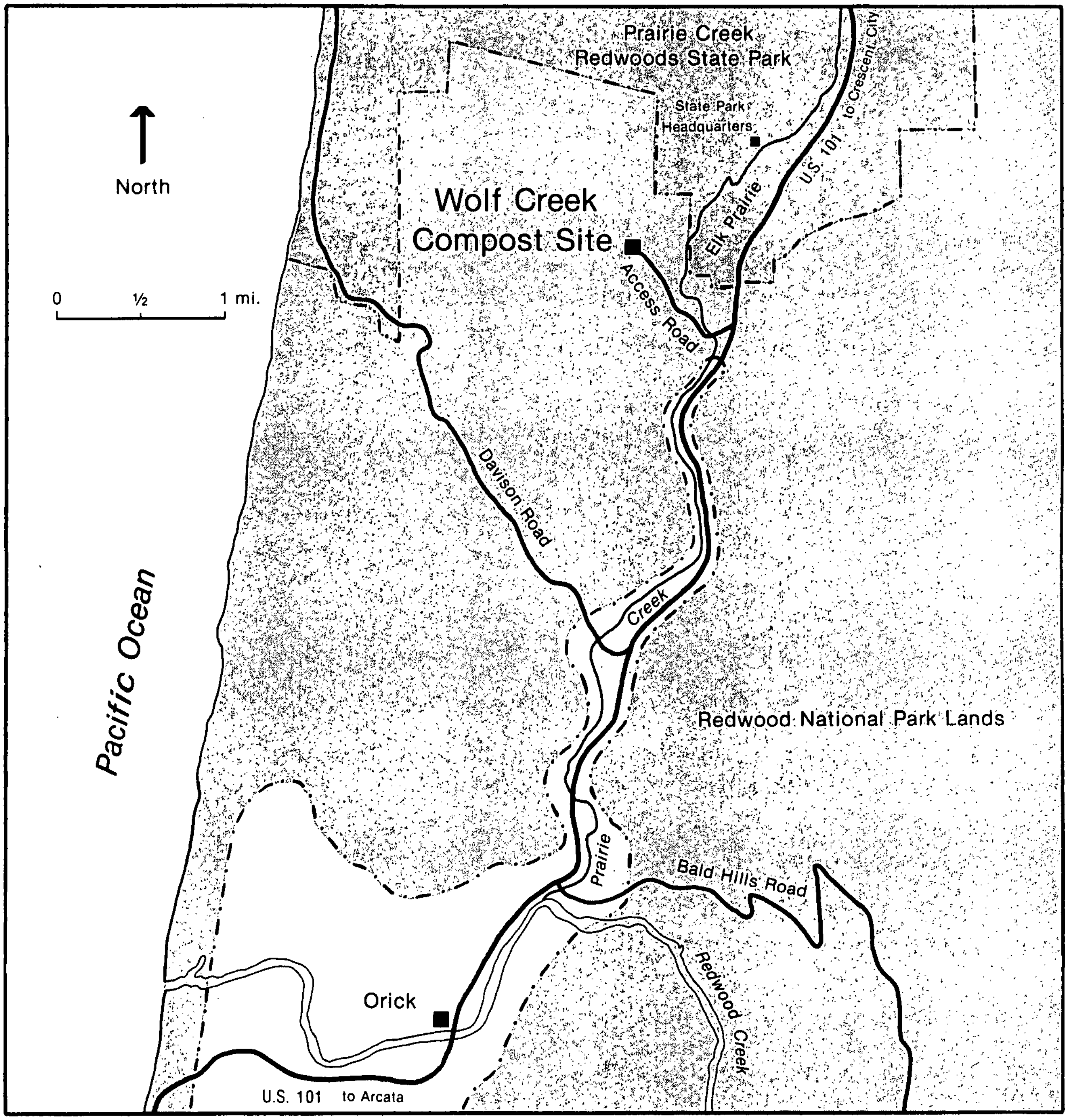
Composting at Redwood was undertaken to prevent a future sewage disposal problem and to provide a by-product useful in the watershed rehabilitation program. Before composting all chemical toilet waste had been disposed at local municipal waste treatment plants or sanitary landfills. Other park sewage is disposed through septic tanks and leach fields. Redwood National Park expects to significantly increase visitor use developments over the next few years as the General Management Plan is implemented. These future developments will increase quantities of effluent requiring treatment. The National Park may have serious problems disposing of additional waste through local municipal treatment facilities.

This compost operations manual is intended to meet Discharge Specification No. 6 of Order No. 81-25, issued by the California Regional Water Quality Control Board, North Coast Region (Appendix C). A copy of the approval letter is contained in Appendix D.

B. Personnel/Division Responsibilities

Composting involves three separate park divisions: maintenance, technical services, and resources management. The maintenance division has primary responsibility for operating the compost system. The maintenance division transports liquid waste to Wolf Creek, operates the compost facility, obtains bacteriological samples, obtains sufficient bulking materials, and

LOCATION
Wolf Creek Compost Facility
REDWOOD NATIONAL PARK



transports finished compost to storage. Maintenance accomplishes day-to-day monitoring of the compost piles.

Maintenance is also responsible for operator training and orientation and implementing emergency procedures. In the event of compost operational problems or effluent spills outside the mixing pads of 20 gallons or more, or any spill into streams, the Chief of Maintenance will be contacted, who will in turn contact the Superintendent; Chief, Technical Services Division; Regional Water Quality Board; and Humboldt County Health Department. Downstream water users will be notified in the event of any spill directly into a stream. Corrective actions, as identified in later sections, will be initiated. Close coordination will be necessary between maintenance, resources management, and the technical services divisions to obtain bulking materials to store compost near future rehabilitation sites, and to conduct monitoring.

Technical services is responsible for any stream monitoring near Wolf Creek, for stream monitoring near landscape spreading areas, for evaluation of composted versus non-composted areas, for assisting with obtaining bacteriological samples, for any research conducted on composting, and for technical advice during composting and landscape spreading.

The resources management division helps provide maintenance with bulking materials from park sources (wood chips, etc.) and is responsible for storage outside of Wolf Creek and landscape spreading during watershed rehabilitation projects.

II. Waste Transport

Chemical toilets and septic tanks are pumped out on a seasonally adjusted, scheduled basis by a National Park Service 1-1/2 ton liquid waste transport truck with a 1,600 gallon capacity. Upon completing the service rounds, the waste material is transported to the compost facilty for storage and composting. All waste unloading occurs on the mixing pad. To discharge the waste material, the truck connects to a quick coupler and pumps into a 6,000 gallon storage tank. The storage tank has an alarm which will sound if waste material approaches storage tank capacity. The waste material in the storage tank is aerated on controlled cycles. In the event of spillage on the mixing pad, the waste material can be contained, pumped out, and the pad cleaned. The mixing pad is designed to contain any waste spillages, from either the truck or storage tank. If spillage occurs outside the mixing pad, the material will be recovered if possible and residue limed. Volumes over 20 gallons or any spill into stream will necessitate implementation of the emergency procedures (see section IB).

III. Compost Operation

A. Facility Description

A site plan of the compost facility is on the next page. Full sets of as-built construction drawings are at the Wolf Creek Compost Office, Requa Maintenance Office, and Crescent City Park Headquarters. The facility consists of three buildings, mixing pad, 6,000 gallon waste holding tank, two open compost areas, a leach field, a 1,500 gallon underground fuel storage tank, a service road, and vehicle parking. A diversion ditch is constructed around the site which incorporates a drop inlet with 18 inch culvert to direct runoff. The facility is fenced with an 8-foot chain link fence. Specific features of the facility include the following:

1. A 2,920 sq. ft. compost storage/fire cache building containing bulking material, finished compost material, utility room, equipment and machinery storage, and fire cache.

2. The 1,900 sq. ft. storage/winter operation building consists of a maintenance storage area, two winter compost pads, blower area, restroom, and office.

3. A 600 sq. ft. storage building is located within the compost site. A 1,500 gallon underground fuel storage tank is located adjacent to this storage building.

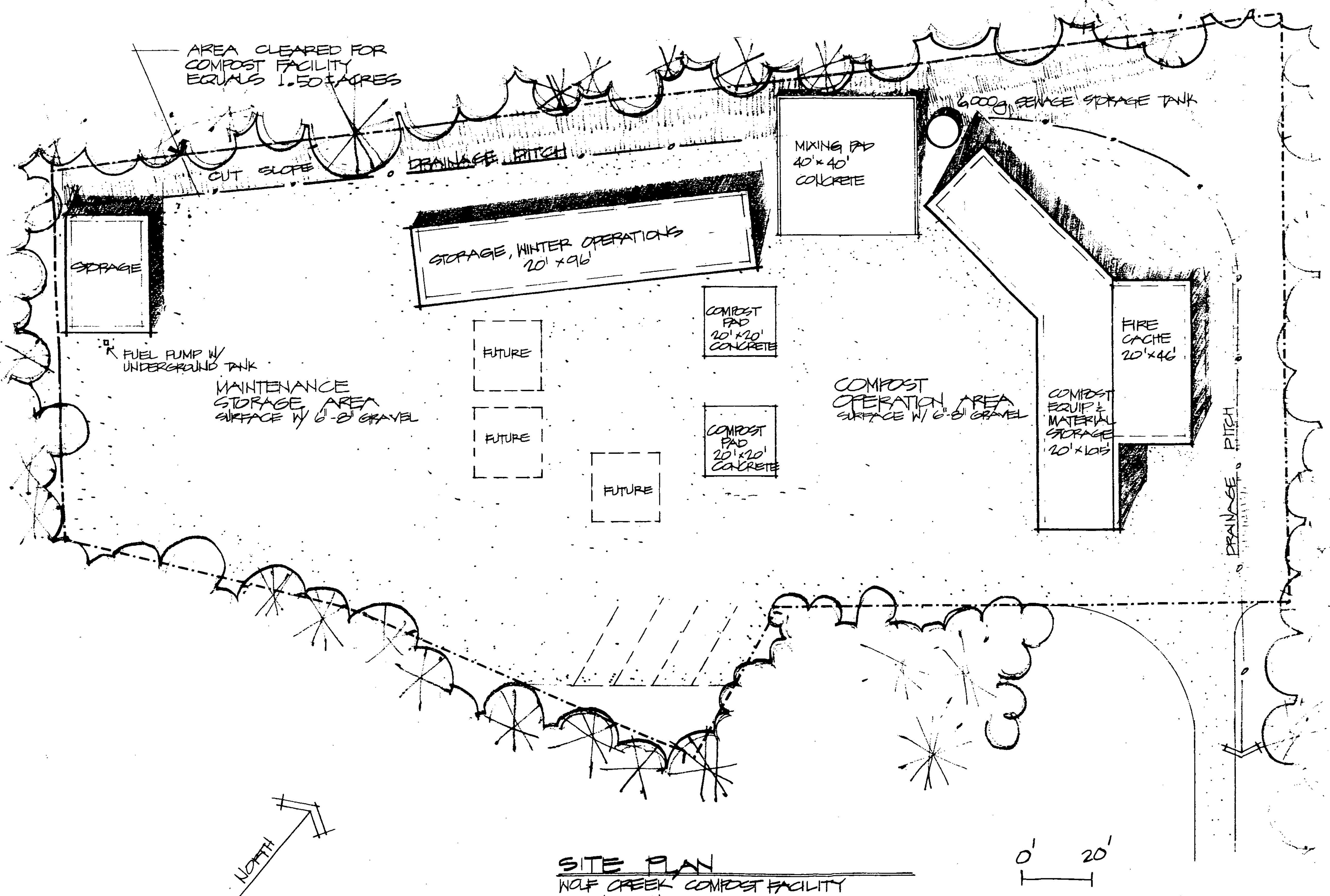
4. The mixing pad is a concrete slab measuring 40' x 40'. The slab slopes to the rear with side walls 3 feet high and a rear wall of 7 feet. A 4-inch drain, with removable cover and screen, is located at the low point of the pad. A valve connects the drain to two leach lines and is used for equipment and pad clean up operations. A second valve in the drain releases winter rain water into the culvert.

5. Initially two open 20' x 20' pads were constructed of concrete and sloped to the center. If necessary, two additional pads can be placed adjacent to the original open compost pads.

6. A diverson ditch around the site diverts any ephemeral drainage and surface water flow around the site. The ditch is sized to handle a 25-year storm, and is designed and constructed to prevent downcutting and erosion.

7. Electrical connections are made from existing sources 800 ft. away. Water is supplied from an existing well 1,300 ft. away. Water is pumped up to a 1,500 gallon storage tank located above the compost facility and gravity fed down to the facility. The water line has a backflow prevention device acceptable to the Humboldt County Health Department. Two 1-inch hose bibbs are available with an emergency shower adjacent to the mixing pad. A 1-1/2 inch fire hose is also located on site.

8. A 6,000 gallon liquid waste storage tank is adjacent to the mixing pad. The tank has a 3-inch supply line and 3-inch air line to provide waste aeration. This tank is vented and screened from odor and vector controlled. The tank also has a fill line indicator with an alarm to indicate tank capacity levels. The tank gravity feeds onto the mixing pad and any accidental leakage or spill will also drain into the mixing pad. The mixing pad is designed to accommodate a complete spill from this storage tank.



SITE PLAN

WOLF CREEK COMPOST FACILITY
REDWOOD NATIONAL PARK
HUMBOLDT CO., CALIFORNIA

solid pipe should be in two pieces to allow drainage of liquid condensate which will collect in the pipe. A modified "t" fixed with a valve should be placed in a trap arrangement to routinely drain the accumulated liquid.

5. A 6 to 8 inch layer of woodchips or other coarse bulking material is placed over the pipe to help prevent the air intake holes in the pipe from clogging with the wet, waste liquid-bulking material mixture (Figure 7).

6. The mixture of waste liquid and bulking material is placed loosely upon the prepared base with the front end loader (Figure 8). The result should be a conical pile, 18 feet in diameter and 8 to 10 feet high.

7. The pile is covered with a 12 to 18 inch layer of bulking material or compost. This layer forms a blanket over the pile to provide insulation. Blanket thickness depends on weather, on ambient temperature, on rainfall, on the type of waste being composted, and on the type of bulking material available. Cooler, wetter weather necessitates a thicker blanket, whereas warmer, dryer weather requires a thinner blanket. Fine-grained material, like old compost, can be used in a thinner (12 inch) blanket whereas coarse bulking agents like woodchips need to be used in a thicker (18 inch) blanket. Septage waste requires a thicker blanket and chemical toilet waste needs a thinner blanket (Figures 9 and 10).

8. Once the pile is set up, the blower should be turned on and the timer checked to insure that it is set to operate correctly. The timing sequence for the blower should be approximately 2 minutes on and 16 minutes off. During the first week, additional air may be necessary to assist in composting. Also, if septage wastes are used, longer exposure to an aerobic condition will be necessary to transfer the mixture from an anaerobic state to an aerobic state.

   Aside from turning on the blower, the only other step is to record the initial temperature and oxygen content at ten locations in the pile (see Figure 11). The recordings are made at the north, south, east, west, and top of the pile, both on the outer edge (1 to 2 feet into pile) and inside the pile (3 to 5 feet) (see Compost Pile Monitoring Report, Form One). Once composting begins, the pile is monitored for temperature and oxygen every three days and the information recorded on the monitoring report (Figure 12).

   At the time the temperature and O_2 are recorded, the blower and timer should be checked to make sure they are operating properly and the pile should be checked for malodors and for any seepage. Malodors (along with low temperatures) may indicate that the pile is operating improperly. Seepage should be absorbed with bulking material and put back into the pile.

9. After the pile is built, excess chips or sawdust are swept up from the mixing pad and placed in the blanket. The mixing pad is washed down with water (the water is drained through the septic tank and

B. Compost Pile Preparation/Set Up

Equipment or materials needed to set up and operate a compost pile include:

1. Front end loader or backhoe.
2. 25 feet of 4-inch perforated plastic pipe (may be reused).
3. 100 feet of 4-inch solid plastic pipe (reusable).
4. 500-1,000 gallons of waste material (see Section III F).
5. About 32 cubic yards of bulking material (see Section III E).
6. Suction fan with timer.
7. Oxygen meter and thermometers.

Procedures:

1. About 20 yards of bulking materials are formed into a saucer-like configuration on the mixing pad (see Figure 1). If several types of bulking agents are used, they must be mixed thoroughly during preparation of the "saucer." It may be desirable to mix the bulking materials the day before pile setup.

2. Approximately 500 to 1,000 gallons of waste liquid are pumped into the saucer (see Figure 2) and allowed to absorb for about 30 minutes (see Figure 3). All mixing of liquid waste is to occur on the mixing pad only. Once the liquid has absorbed for 30 minutes, the front end loader is used to mix the waste and bulking material (see Figure 4). The liquid and bulking material must be thoroughly mixed so that complete absorption takes place and lumps are no larger than 3 inches in diameter. If lumps of waste are larger than this, a slow rate of decomposition and suboptimal temperatures may result (Willson, 1980).

3. While the waste liquid is being absorbed into the saucer of bulking material, a mattress of bulking material is prepared on the compost pad (see Figure 5). Thoroughly mixed bulking material or compost is placed in a circular configuration on the pad about 18 feet wide and 1 foot deep. The base or mattress absorbs excess moisture that may leach from the pile.

4. A loop of 4-inch diameter perforated pipe is placed on the mattress (see Figure 6). The perforated pipe should extend no closer than 18 inches of the end slopes of the pile because too much air may be pulled through the sides of the compost pile, causing localized "cold spots" that do not reach the thermophilic range (Willson, 1980). The perforated pipe is attached with a "T" or "Y" connection to a length of 4-inch diameter solid pipe which is connected to the suction blower. The solid pipe should have a damper in it to help control the volume of air pulled through the pile. Also, if more than one pile is on a blower, a damper will be necessary to adjust and equalize the airflow through both piles. In any case, the length of

Figure 1: Bulking material is thoroughly mixed on the mixing pad and shaped into a saucer. All photographs are by the author and were taken in July 1982.

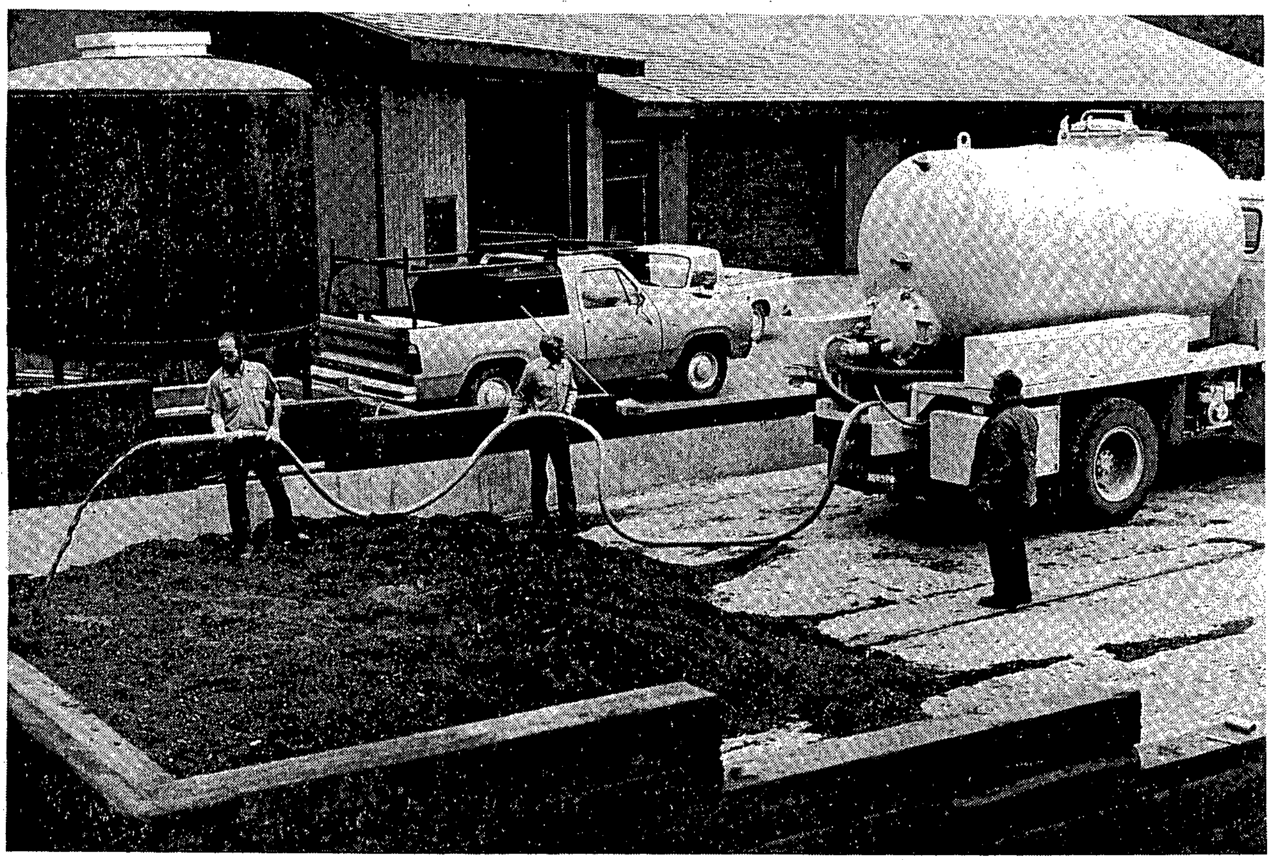


Figure 2: Raw waste is pumped from the truck into the saucer of bulking material. The large tank on the left is the waste liquid storage tank. The building in the background is used to house the liquid waste transport truck (left door) and to store bulking materials and finished compost (right doors).

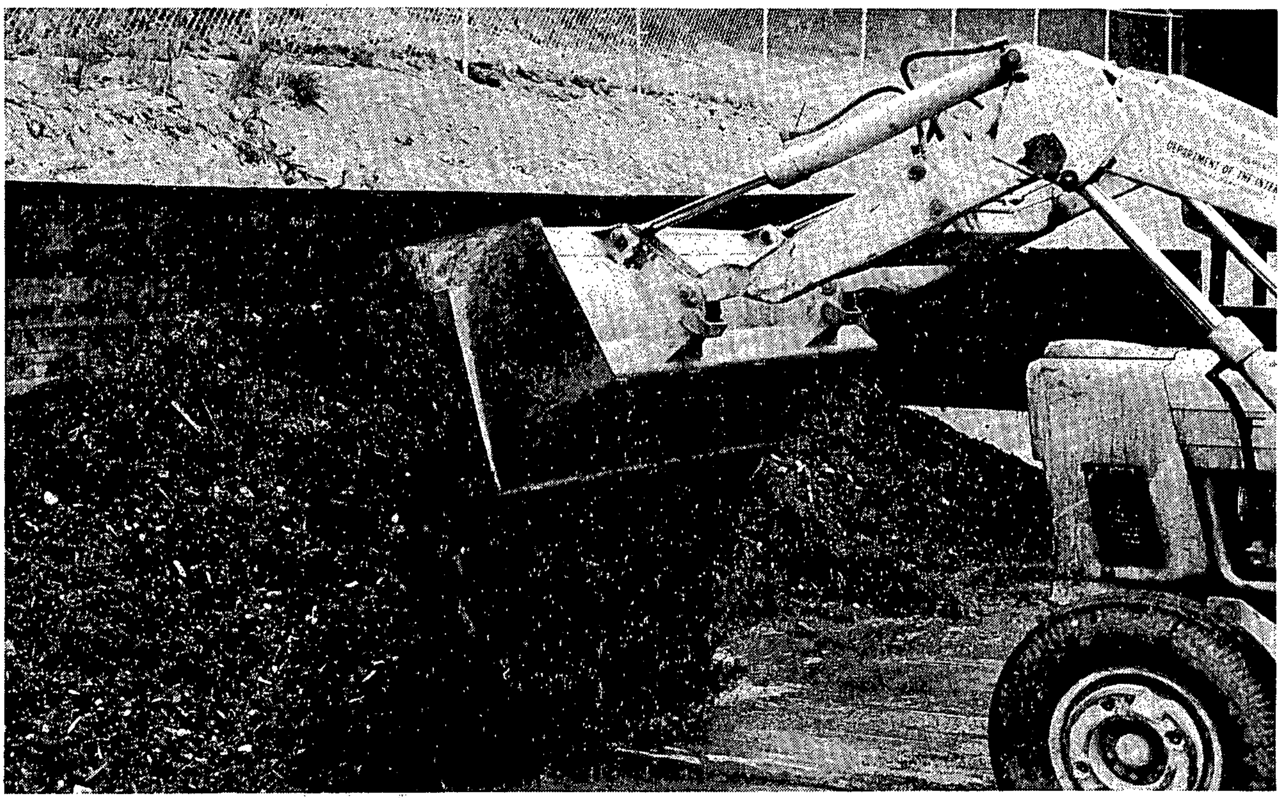


Figure 3: Liquid waste is allowed to absorb for about 30 minutes.

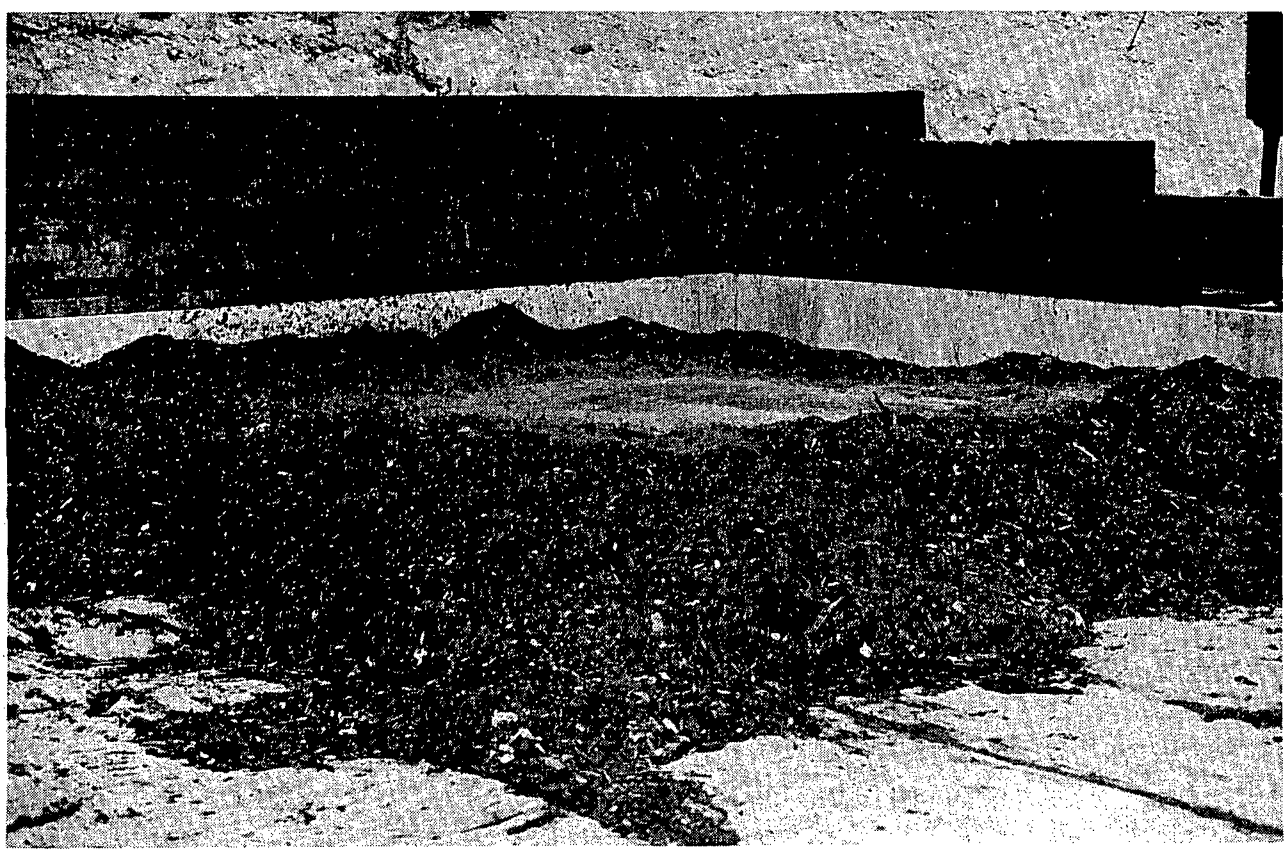


Figure 4: The liquid waste/bulking materials are thoroughly mixed to evenly distribute the liquid waste and insure full absorption.

Figure 5: A twelve inch thick mattress is prepared on the compost pad.

Figure 6: A loop of four inch perforated pipe is laid in the center of the mattress.

Figure 7: The perforated pipe is covered with coarse wood chips to help prevent the liquid waste/bulking mixture from clogging the holes in the pipe and reducing air flow through the pile.

Figure 8: The bulking material/waste liquid mixture is transferred from the mixing pad (background) to the compost pad.

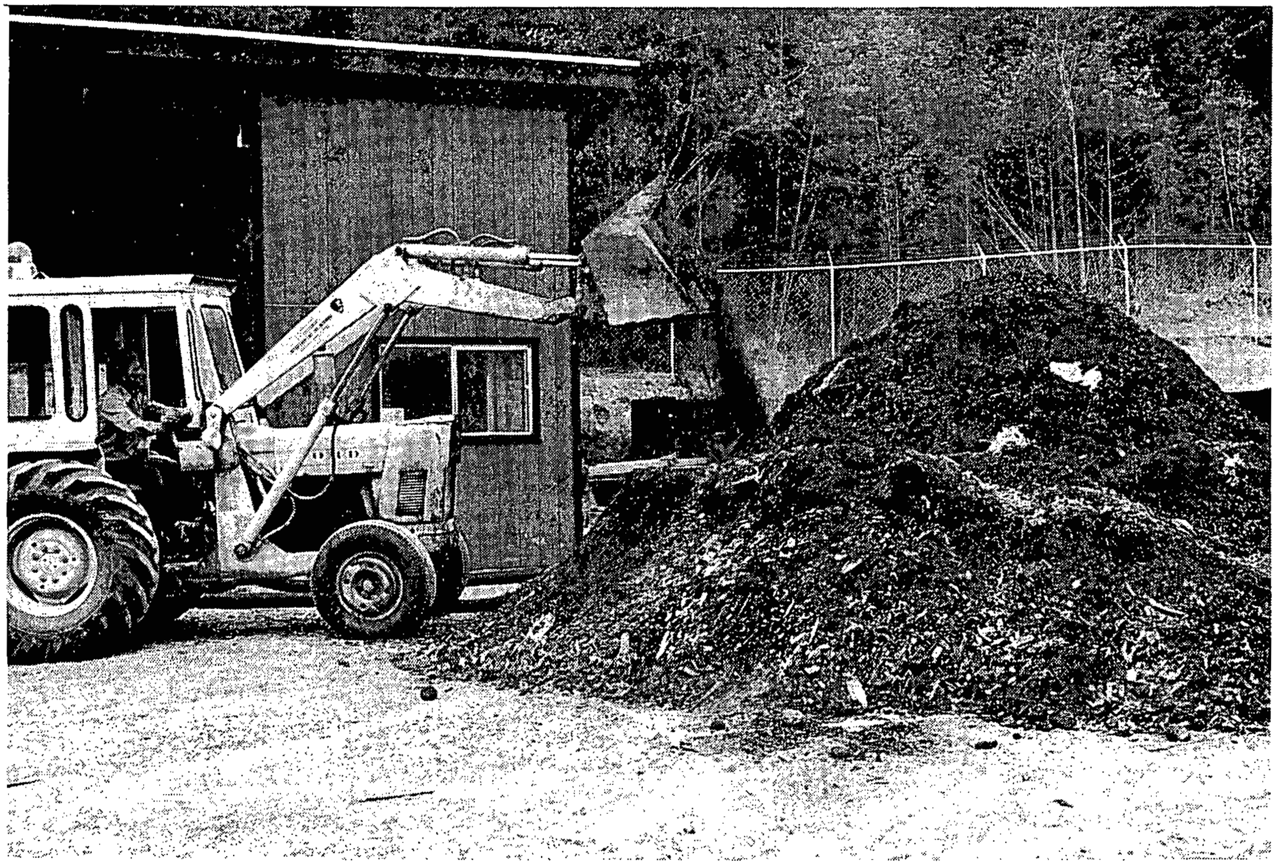


Figure 9: An insulating blanket of old compost and woodchips is poured over the pile.

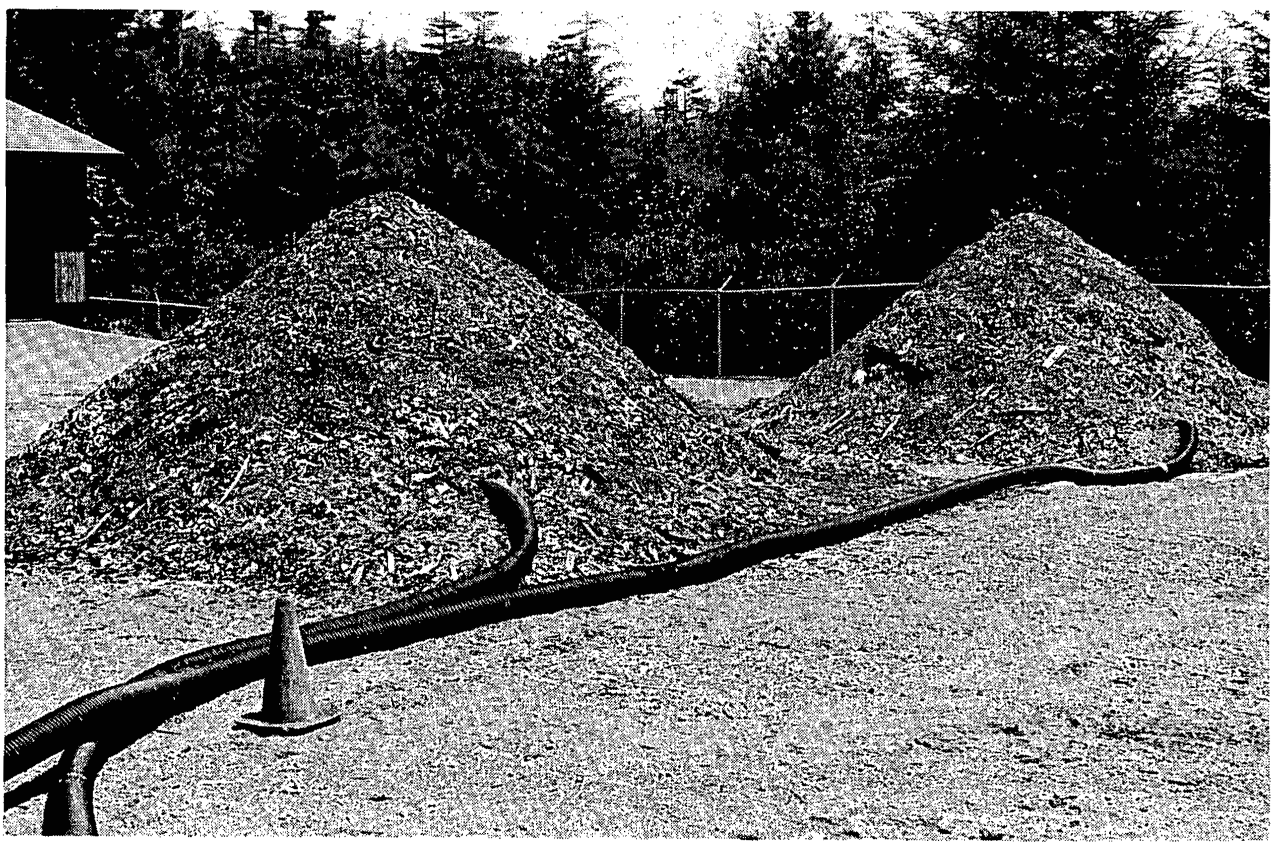


Figure 10: Completed compost piles.

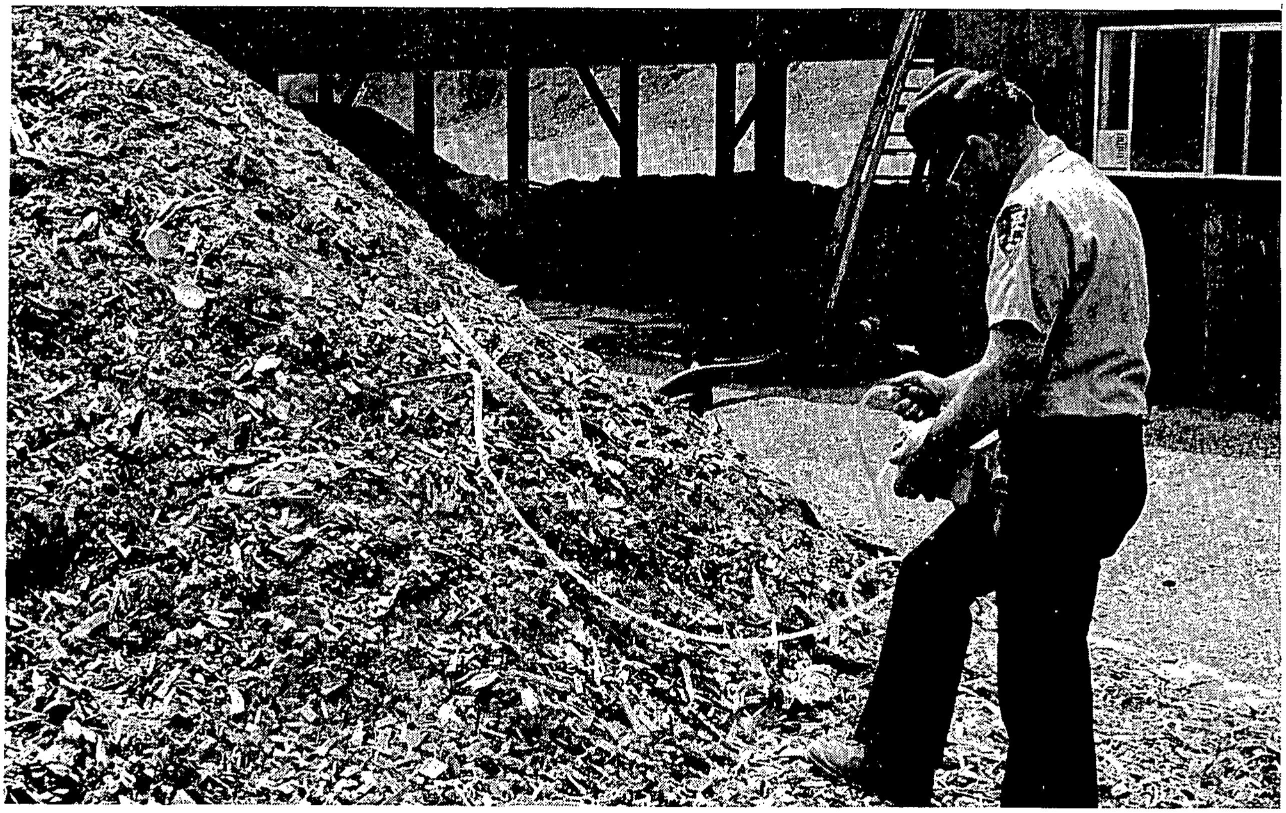


Figure 11: Oxygen and temperature are recorded every three days. In the background are the office (right), blower, and covered winter compost pads.

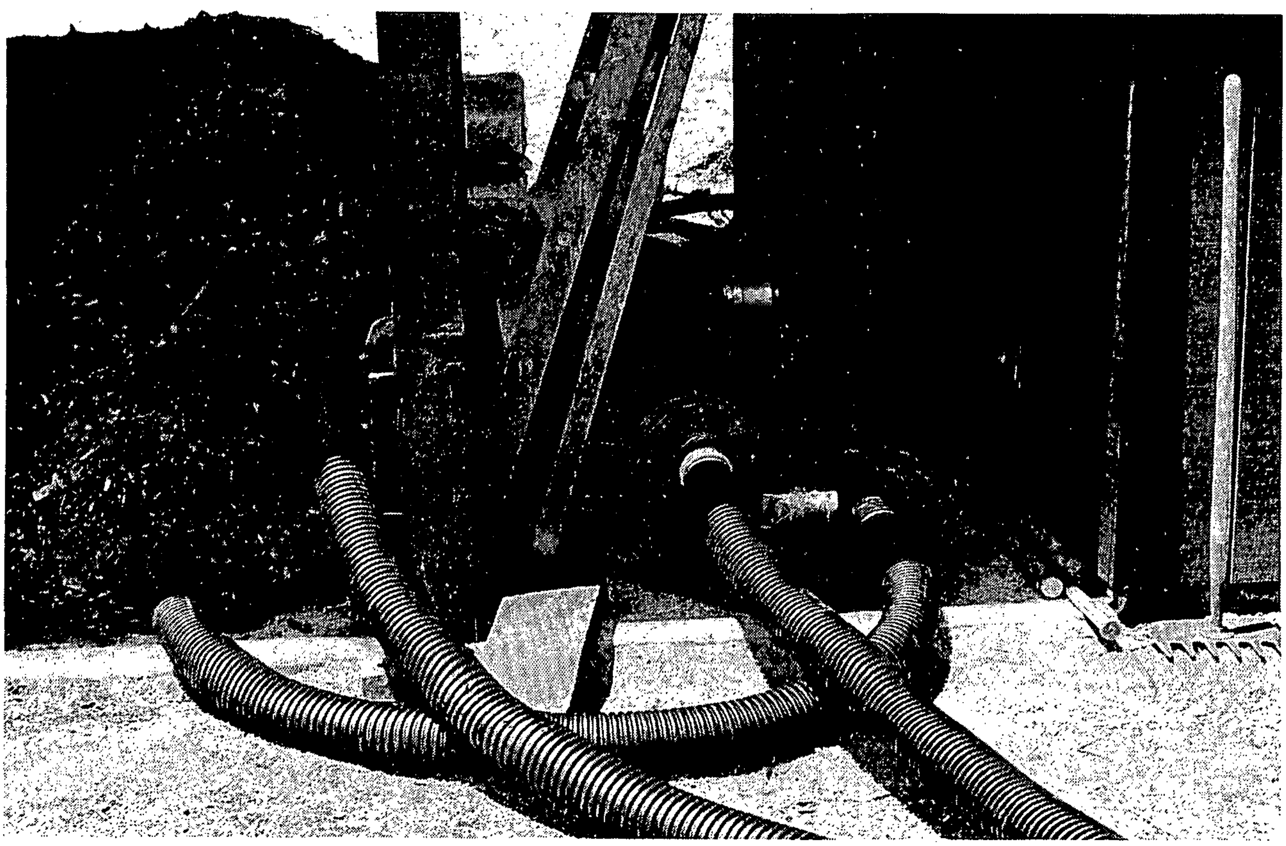


Figure 12: The blowers are placed in a protected breezeway and exhaust gas is vented into a pile of chips and old compost.

Figure 13: After building a pile, the mixing pad is swept, washed down, and limed.

Figure 14: Breaking down a completed compost pile.

into the leach field) and lime is spread over the pad, including the sidewalls. The same procedures will be used for the outdoor compost pads in late September when outside composting is completed. If another pile will be built in a day or two and no rain is forecast, the mixing pad need not be cleaned (Figure 13).

C. Composting

Five components are necessary to make composting work: bacteria and fungi, nitrogen, carbon, moisture, and oxygen. The bacteria and fungi are available from previous compost piles. Initially manure was used to supply the appropriate bacteria and fungi to the compost piles. Nitrogen and moisture come from the liquid waste. Carbon is supplied by the bulking materials. Oxygen is provided by the blower. Bacteria and fungi use carbon as an energy source to actually accomplish composting. Nitrogen and oxygen are necessary for the microorganisms to utilize carbon. Heat generated by the activity of the bacteria and fungi will result in the pile reaching temperatures of 55°C or above.

Composting proceeds at a rapid rate under optimum conditions and each pile should compost in about 21 days.

The conditions or parameters for successful composting are:

Temperature: Temperature is the key indicator that the process is working correctly and 55°C to 60°C in the pile is optimum. A temperature reading of 55°C or above must be maintained for five days in order to assure destruction of disease causing microorganisms. Too high a temperature (above 65°C) results in the destruction of beneficial microorganisms. If the pile gets too hot, the oxygen flow should be increased.

Oxygen: 10% (high oxygen readings [20-21%] may indicate that the blower is operating too frequently and may be cooling the pile).

Moisture Content: Above 45%; however, not saturated.

Carbon/Nitrogen Ratio: 20/1 or 25/1.

pH: 6.0 to 7.5.

Although the above are optimum conditions, only oxygen levels are manipulated during composting. Proper moisture content results from mixing adequate quantities of bulking material with liquid waste and protecting compost piles from heavy winter rains.

D. Trouble Shooting

Potential problems during composting and solutions include:

Raw Waste Spill (at Compost Site): Use bulking material to absorb excess liquid. Spread lime over areas after absorbing excess.

Algae Bloom: May occur where raw waste was spilled and not adequately cleaned up. May also occur in the vicinity of the mixing pad or compost pads where liquid waste or raw compost has spilled. Lime area.

Seepage: Excess liquid may seep out of pile during composting. Use bulking material to absorb excess liquid and lime area.

Rain: No composting will occur outside (uncovered) from October 1 to May 1. No mixing shall occur while it is raining. If heavy, unseasonal rains are forecast, any uncovered compost will be covered with plastic and the plastic will be secured to help keep it from blowing away.

Odors During Composting, Low Temperature, Low Oxygen Per Cent: All are indicators of an improperly composting pile. The pile can either be broken down and re-piled or a thicker blanket should be applied and air flow increased.

Odor Control (from Willson, et al., 1980): Although sewage can emit a strong unpleasant odor, this odor gradually disappears as the waste is stabilized by composting. All odor cannot be eliminated during composting, however. Even well-cured composts have an earthy odor that is pleasant to most people. Each of the unit operations can be a potential source of odors. Some of the odors are emitted intermittently and others continuously. Odor potential increases considerably during and immediately after heavy rain. To minimize the odor potential throughout the composting process, one must manage each operation as follows:

1. The Mixing Operation: Prompt mixing of waste liquid and bulking material and placement of the mixture in the aerated pile reduces the time for odor generation.

2. Aerated Pile Surface: This will not be a source of strong odors if the blanket of compost is adequate for insulation. Thin spots or holes in the blanket will be a potential source of odors. The effectiveness of the blanket for odor control decreases when its moisture content exceeds 60%.

3. Air Leakage Between the Blower and Odor Filter Pile: Since air leakage can occur at this point, all pipe joints should be sealed with duct or similar tape. Back pressure from the odor filter pile should be minimized to prevent gaseous losses around the blower shaft. A layer of woodchips over the perforated pipe will minimize back pressures.

4. Odor Filter Piles: Odor filter piles should be cone-shaped and symmetrical, and should contain about one cubic yard of dry (50% moisture or less) screened compost. A compost cone of woodchips over the pipe outlet will reduce pressure through the pile.

5. Leachate: If liquids drain from the compost pile, bulking material should be used to absorb any excess liquid and the area should be limed.

6. Condensate: Liquid formed from warm, moist air leaving the pile and condensing in the cooler ambient air does not have to be treated.

7. Storage Piles: Piles should not be constructed with excessively wet compost (above 55% moisture). These also can be a source of odors if

the material removed from the aerated pile has not been completely stabilized. If waste liquid is incompletely composted after 21 days because of excess moisture, low temperatures, or improperly constructed piles, it should not be put on a regular curing pile. Instead it should be mixed with additional bulking material and composted another 21 days with aeration.

8. Waste Liquid/Bulking Material: When pools of waste liquid, even though small, are allowed to remain on the compost pad after mixing and processing, they soon emit unpleasant odors. All excess waste should be carefully removed from the mixing areas as soon as possible.

E. Bulking Materials

Five types of bulking material are used:

1. Wood Chips: From park-derived material or purchased commercially. Wood chips do not absorb large quantities of liquid, but are useful in maintaining a coarse bulking agent mixture which aids airflow through the pile.

2. Sawdust: From park-derived material or purchased commercially. Sawdust contains large amounts of carbon relative to nitrogen and a high carbon-nitrogen ratio will slow the compost process. Dry sawdust is the most absorbant material.

3. Shredded Paper: From park offices. Shredded paper should not exceed 10% because it tends to mat down and form lumps when mixed with liquid.

4. Compost: After the first pile or two, compost is available for use as bulking material.

5. Miscellaneous Plant Material: Leaves, needles, grass clippings, chipped branches, etc.

No matter which bulking agents are used, they must be dry in order to absorb liquid waste.

The proportions of bulking materials to use has not been established; however, Patterson (1979b) uses two parts woodchips, two parts sawdust, and one part compost. Redwood uses similar ratios, but will substitute other bulking materials as they are available.

F. Liquid Waste

Liquid waste supplies a critical component necessary for composting: nitrogen. The primary effluent to be composted is liquid waste from chemical toilets. Fresh chemical toilet waste is an excellent source of nitrogen. Other waste materials, septic tanks pumpings or effluent from sewage treatment plants, can be composted; however, both tend to be deficient in nitrogen.

Nitrogen is rapidly used up under the anaerobic conditions in a septic tank while sewage treatment plants also remove nitrogen as they process the waste. As a result both should be mixed with fresh chemical toilet waste so that sufficient nitrogen is provided.

G. Monitoring/Record Keeping

Monitoring is important to satisfy permit requirements, to insure the process is working correctly, and to assure a safe and useable end product. Accurate measurements and record keeping are the only means by which success or failures of a pile can be judged and the reason for the success or failure determined. Without accurate records, the park will never know why a pile did not work. In the long-term, temperature and oxygen readings along with records of bacteriological, nitrogen and other tests will help confirm the validity of the waste discharge requirements and prove that compost is safe and useable. The maintenance division records the data on the forms provided, which are kept on site.

Three monitoring forms used to record data regarding compost operations. The first (Form 1) serves as a place to record information about a compost pile during composting and the second (Form 2) is used during storage and during landscape spreading. The third (Form 3) is used to keep track of liquid waste and bulking agents stored at Wolf Creek. Examples of each form are on the next pages.

Additional tests and monitoring may be performed during composting to provide additional information about the process and product. For example, monitoring of insect vectors could occur during composting along with more extensive chemical and microbiological testing following composting.

Form 1

Redwood National Park
Wolf Creek Compost Project

Pile Number____________

Compost Pile Monitoring Report

Date of pile construction____________________________ Recorder____________________________

Date of re-mix (if necessary)____

Date of dismantling____________________________ Recorder____________________________

Type and quantity____

____

Type and quantity of bulking agents____

____

____

Bacteriological Monitoring (Attach lab results)

Date of samples____________________________ Recorder____________________________

Results	#1	Total Coliform______________	Fecal Coliform______________	Fecal Strep.______________
	#2	Total Coliform______________	Fecal Coliform______________	Fecal Strep.______________

Comments

____

Instructions

1. One form is to be filled out for every pile.
2. Quantity of waste should be estimated in gallons.
3. Quantity of bulking agents should be estimated in cubic yards.
4. Bacteriological monitoring occurs at the end of active composting. Two composite samples shall be taken from each compost pile and analyzed for total coliform, fecal coliform and fecal streptococcus. Each composite sample shall be composited from samples taken at four locations distributed evenly throughout the pile. The actual lab results should be attached to this form.
5. Temperature and oxygen samples need to be taken every three days at ten locations distributed evenly throughout the pile. Samples taken "inside" should be measured about 3 to 5 feet into pile; samples taken "outside" should be about 1 to 2 feet into pile.
6. Under comments, note any unusual activities or why the pile had to be re-mixed.
7. Blower setting should be noted (number of minutes on per minutes off, for example 2/15 would means two minutes on, 15 off.).
8. Air temperature is outside air temperature at Wolf Creek. Wet/dry bulb temperatures should be recorded.
9. The oxygen meter turned off and recapped; the recorder should initial that this has been accomplished.
10. Copies of the monitoring report forms should be sent to the Regional Water Quality Control Board on a monthly basis.

Temperature/Oxygen Data

Pile Number ______

Date of Construction ______

Pile Location			Recording Date/Time (every third day) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
North	inside	temp / O_2																	
	outside	temp / O_2																	
East	inside	temp / O_2																	
	outside	temp / O_2																	
South	inside	temp / O_2																	
	outside	temp / O_2																	
West	inside	temp / O_2																	
	outside	temp / O_2																	
Center	inside	temp / O_2																	
	outside	temp / O_2																	
Recorder (initials)																			
Air Temperature wet/dry																			
Oxygen Meter Off ? (initials)																			

Form 1 (back)

FORM TWO

Redwood National Park
Wolf Creek Compost Project

STORAGE/LANDSCAPE SPREADING REPORT

Storage:

Date Stored: ____________________

Date Removed: ____________________

Where Stored: ____________________

Comments: ____________________

____

____

Landscape Spreading:

Date Spread: ____________________

Where: ____________________

Comments: ____________________

____

____

Stream Monitoring (attach lab results):

Date of Storm	Above Site		Below Site	
	Total N	fecal coliform	Total N	fecal coliform

FORM THREE

Redwood National Park
Wolf Creek Compost Project

Liquid Waste/Bulking Materials
Receiving Report

Date	Type of Material	Quantity

IV. Compost Storage

The finished compost material shall be stored for a minimum period of six months after active composting and before it is applied to land. The storage period is intended to allow the compost to stabilize and to help insure that all pathogens have been destroyed. Composting will continue during storage, although probably at a much slower rate than during initial composting (Willson, 1980).

Compost should be stored in piles, similar to the piles created for actual composting. Several compost piles may be mixed together and the material may be piled as high as convenient. The tops of the storage piles should be rounded so that wet pockets do not develop, but the piles do not have to be covered. (Willson, 1980). The compost should be stored well away from perennial streams and the actual storage piles should be located to avoid obvious surface runoff sites.

Storage piles will be monitored during storms to insure that excessive leaching is not occurring and that piles are intact. The technical services division of the park will be responsible for monitoring compost while in storage. Compost shall only be stored at approved sites. As of August 1, 1981, the approved sites for storage are:

Wolf Creek Compost Site
Upper Miller Creek 1978 Rehabilitation Site
C-30/W-Line Road Rehabilitation Site

Use of any other site for storage requires approval of the Regional Water Quality Control Board. Sites expected to be used for storage include:

G-Line Deck
A-9 Deck
Ingomar Club Area
Lower K & K Road
Y-Line Rock Pit #1
Requa Radar Station

Record keeping requirements during storage include: Noting when a pile is stored (the date should correspond to the date the pile is dismantled); noting where the pile is stored; and recording the date the pile is removed from storage for landscape spreading.

It is expected that a number of piles will be mixed together during storage. If such mixing occurs, the whole pile shall be stored for at least six months from the date of adding the newest material. If mixing occurs in storage, piles of approximately the same age should be mixed to avoid excessively long storage periods. Monitoring record sheets for mixed piles should be attached together.

V. Landscape Spreading

Compost will be used as a soil amendment during watershed rehabilitation projects and will be applied to pulled roads where soil is almost nonexistent. Compost is intended to improve soil physical properties, including enhanced aggregation, increased soil aeration, lower bulk density, less surface crusting, increased water infiltration, and increased water retention (Hornick, 1979).

Application rates for compost have not been established. Table A (from Hornick, 1979) gives some suggested quantities for sewage sludge compost. Redwood will only be using compost as a soil amendment during watershed rehabilitation projects. Use on vegetables, legumes, and in public use areas is not authorized.

Compost is a low analysis fertilizer with nitrogen, phosphorus, and potassium being under 2%, on a dry weight basis. Compost application rates are not expected to reach fertilizer levels. For example, the park has used 16-20-0 fertilizer at an application rate of 200-250 pounds per acre on rehabilitation sites. Compost would need to be applied at about 3,200 per acre (if N content of the compost was 2%) to equal current fertilizer rates. In addition, the nitrogen in compost is in organic form and must be mineralized to inorganic ammonium or nitrate before it is available for plants (Epstein, n.d.).

The guidelines for landscape spreading are:

1. Only compost stored six months or more may be used.
2. Landscape spreading may only be conducted from May 1 to October 1 each year.
3. All compost is to be worked into the soil. No compost shall be simply spread over the hillslopes.
4. Compost may only be spread in areas with less than ten per cent slope.
5. Compost may not be spread within 100 feet of surface waters, ephemeral drainages, springs, or marshy areas.
6. Landslides and gullies are to be avoided.
7. All areas that are composted will be seeded and protected from surface erosion.
8. No compost shall be discharged into surface waters.
9. All sites will be approved by the Regional Water Quality Control Board Executive Officer prior to use.

Approved locations for landscape spreading within the Redwood Creek Basin are:

1. Upper Miller Creek 1978 Rehabilitation Unit.

2. W-Line Rehabilitation Unit.

Procedures for application will vary. Initially for testing purposes, compost will be spread with hand tools and worked into the soil using a rototiller. As application rates and procedures are worked out, it is expected heavy equipment will be used to spread and work the compost into the soil.

Record keeping requirements include noting where and when a pile is spread and monitoring water quality above and below land application areas (see Form 2). Total nitrogen and coliform levels are to be monitored during storm runoff periods from October 1 to May 1 following application.

TABLE A

VARIOUS USES AND APPLICATON RATES OF SEWAGE SLUDGE COMPOST

TO ACHIEVE FERTILIZER BENEFITS AND SOIL IMPROVEMENT[3]

(from Hornick, et al., 1979)

Use	Compost per 1,000 square feet[1]	Remarks
	Pounds	
Turfgrasses:		
Establishment:		
Soil Incorporated	2,000 - 6,000	Incorporate with top 4 - 6 inches of soil. Use lower rate on relatively fertile soil and higher rate on infertile soil.
Surface Mulch	600 - 700	Broadcast uniformly on surface before seeding small seeded species (bluegrass) or after seeding large seeded species (fescues).
Maintenance	400 - 800	Broadcast uniformly on surface. On cool-season grasses apply higher rate in fall and again in early spring.
Sod Production When:		
Incorporated with Soil	3,000 - 6,000	Incorporate with 4 - 6 inches of soil.
Unincorporated with Soil	6,000 - 18,000	Apply uniformly to surface. Irrigate for germination and establishment.
Vegetable Crops:		
Establishment	1,000 - 3,000	Rototill into surface 1 - 2 weeks before planting or in previous fall. Do not exceed recommended crop nitrogen rate.
Maintenance	1,000	Rate is for years after initial garden establishment. Rototill into surface 1 - 2 weeks before planting or in previous fall.
Reclamation:		
Conservation Planting	Up to 9,200	Incorporate with top 6 inches of soil. Use maximum rate only where excessive growth for several months following establishment is desirable. For each inch beyond 6 inches of incorporation, add 1,000 pounds per 1,000 square feet on soils where ground-water nitrogen will not be increased.
Mulch	300 - 700	Broadcast screened or unscreened compost uniformly on surface after seeding; unscreened is more effective.

TABLE A (Continued)

Use	Compost per 1,000 square feet[1]	Remarks
	Pounds	
Field Crops:		
Barley, Oats, Rye, Wheat	1,000 - 1,300	Incorporate into soil 1 - 2 weeks before planting or in previous fall.
Corn	3,000 - 3,800	Incorporate into soil 1 - 2 weeks before planting. Supplemental potash may be required depending on soil test.
Legumes[2]	---	Legumes can be grown in rotation with corn, oats, or other nitrogen-requiring crops.
Forage Grasses:		
Establishment	4,000 - 7,000	Incorporate with top 4 - 6 inches of soil. Use lower rate on relatively fertile soil and higher rate on infertile soil. Supplement during first year's growth with 1/2 pound per 1,000 square feet (25 pounds per acre) of soluble nitrogen fertilizer when needed.
Maintenance	1,000 - 1,300	Broadcast uniformly on surface in fall or early spring 1 year after incorporated application.
Nursery Crops and Ornamentals (Shrubs and Trees):		
Establishment	1,900 - 7,000	Incorporate with top 6 - 8 inches of soil. Do not use where acid-soil plants (azalea, rhododendron, etc.) are to be grown.
Maintenance	200 - 500	Broadcast uniformly on surface soil. Can be worked into soil or used as a mulch.
Potting Mixes	---	Thoroughly water and drain mixes several times before planting to prevent salt injury to plants.

1: 1,500 pounds per 1,000 square feet is equal to 1/2 inch of compost per 1,000 square feet or 33 wet tons per acre based on 40 percent moisture content and 1/2-inch mesh-screened material.

2: Legumes, such as alfalfa and soybeans, do not need all the nitrogen fertilizer supplied by the compost. Maximum benefit of compost as a fertilizer can be realized by growing legumes in rotation.

3: Use of compost on crops, legumes, and in public use areas is prohibited by the Regional Water Quality Control Board.

VI. References

All references are available in the Arcata office, Redwood National Park

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1980 Manual for Composting Sewage by the Beltsville Aerated-Pile Method. Report No. EPA-600/8-80-022. U.S. Environmental Protection Agency, Cincinnati, Ohio.

Appendix A: Parts List/Manufacturer Information

THERMOMETERS:

Bi-Metal Dial Thermometer: Model H
36-Inch Stem Length
Pointed Stem

Range: 0°C - 100°C

Manufacturer: Reotemp Instrument Corporation
San Diego, California

Order Through: Abbeon-Cal, Incorporated
123 Gray Avenue
Santa Barbara, California 93101

OXYGEN ANALYZER:

Model 320 B/RC
Teledyne Analytical Instruments
Teledyne, Incorporated
P.O. Box 1580
La Puente, California 91749

Appendix B

RAW WASTE RECYCLING THROUGH STATIC PILE COMPOSTING

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National Park Service

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National Technical Information Service
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RAW WASTE RECYCLING THROUGH STATIC PILE COMPOSTING

J.C. Patterson and J.R. Short
National Park Service, Ecological Services Lab

Abstract

Production of concentrated human waste is realized in areas where traditional sewage systems are non-existent. Wastes can be generated from a number of different systems, such as: sanitary toilets at construction sites or in remote areas, pumpings from septic tanks, oil flush toilets, recreational vehicle waste discharges, and numerous other waste producing systems.

In 1975, the National Park Service was faced with a severe waste disposal problem along the Chesapeake and Ohio Canal National Historical Park. The canal and its towpath parallel the Potomac River from Georgetown to Cumberland, Maryland. Along the towpath, and at visitor access points to the river, are located sanitary toilets from which raw waste was traditionally disposed of into local treatment plants; however, without warning, disposal permission was forbidden. Alternative disposal methods were considered. Ultimately, the static pile composting technique developed by USDA at Beltsville was altered to handle this liquid waste.

After successfully composting sanitary waste along with some septage, an EPA grant was obtained to fully characterize the composting process for both sanitary toilet waste and septage. Both materials have been successfully composted yielding a quality soil conditioner for use on the Park's recreational lands.

Introduction

Environmental awareness on the part of the public has caused some re-thinking of our waste disposal techniques. Innovative processes have lead to a number of new treatment techniques which tend to produce valuable organic resources from waste. One such notable development has been the aerated static pile composting system developed by the USDA at Beltsville, Maryland.

Technology generated by Beltsville has been the springboard for numerous satellite composting facilities. As a result of this outstanding work, the National Park Service gave serious consideration to treatment of raw liquid wastes via the static pile system.

Chesapeake and Ohio Canal National Historical Park was faced with a serious waste disposal problem in 1975. Local municipal treatment plants could no longer accept the C & O's waste materials. Alternative treatment and waste handling techniques had to be considered. Liquid waste, such as that generated from the sanitary toilets is a problem waste with which to deal. In general, municipal treatment facilities do not accept more than 3% of their total loading potentials as raw concentrated waste; therefore, workable alternatives had to be found and the canal decided to modify the static pile system to receive raw liquid waste as was common to the park.

In 1975, an environmental assessment was processed and site preparation completed for the installation of a static pile composting system on park lands near the canal. In June, the first setup was attempted with some reservations. By the third trial, success was realized and the system proved, with some modifications, to be quite suitable for liquid waste composting. During 1976 and 1977, successful treatment of both sanitary waste and a mixture including some septage was realized.

The Environmental Protection Agency (EPA), in 1978, provided a research grant to fully characterize the composting process with regard to treatment of both sanitary waste and septage.

Literature Review

Composting of dewatered sewage sludge has become a recognized treatment alternative (References, #1). Generally dewatered sludge has been combined with wood chips, thoroughly blended and composted by the windrow or aerated static pile method. The method has been highly adaptable to many differing climates and sizes of operations from rather small communities such as Durham, New Hampshire, to much larger metropolitan areas such as Philadelphia, Pennsylvania, and Washington, D.C. However, not all of the sludge produced within these localities is being composted at present, future projections are to compost most or all of the material produced.

Treatment of raw liquid wastes such as septic tank grey water (septage) or concentrated sanitary toilet wastes had traditionally been a problem with which to deal for traditional treatment plants. Recently successful composting facilities have become functional in Washington state, Boston, Massachusettes area, the U.S. Forest Service in the northeastern United States, and along the Chesapeake and Ohio Canal National Historical Park. Each system is somewhat unique but each achieves the desired end product of compost.

Perhaps the initial composting facility for septage wastes was the Lebo process (References, #9). During the process, the pumper truck discharges liquid waste into a receiving tank from which, the waste is released into the Lebo Aerator. The aerator is a conical aerator through the bottom of which compressed air is forced producing a helical swirling motion such that the waste undergoes a violent aeration for about 15 minutes. This action tends to reduce odors and eliminate large clumps of waste prior to transfer through a "U" tube and spraying onto a bed of sawdust or wood shavings where thorough blending is achieved. The mixture is then transferred to the compost pile. Alternating layers of septage-sawdust are used until a pile height of 2.5 - 3.0 m (8 - 10 ft) is obtained. Pile configuration is generally square with a flat top maintained to prevent excess heat loss. A composting period to 30 - 90 days is common for treatment.

Pio Lombardo, P.E. of Boston, Massachusetts, has utilized the static aerated pile and a manual turning method of composting with success in the northeast U.S. (References #5 and #6). In 1977, the closing of a municipal treatment plant forced three towns to seek alternative septage waste treatment systems. The system used is described in the literature, additional details of liquid waste composting will be discussed in this paper. However, it is significant to note that Mr. Lombardo has achieved considerable success using the forced aeration method of composting. Pilot studies were so successful that funding for a regional septage composting facility is being pursued.

U.S. Forest Service scientists in Durham, New Hampshire, have used several self-composting toilet systems within remote backcountry sites (References #2, #3, and #4). However, high costs of individual units, necessitated a study of alternatives. At present, the Forest Service has developed and had considerable success with individual composting bins for single toilet facilities. These prefabricated boxes are easily backpacked to remote areas and assembled. Bark chips are carried to the site placed within the bin. Liquid waste from individual toilet systems is transferred onto the bark chips. A hand blending of the mixture and the composting function is underway. Generally, three to four weeks is required for proper treatment. Aeration of the composting mixture is enhanced by PVC pipes placed through the bins and composting mixture. Composts generated are utilized on-site to reduce human impact to heavily used areas.

Results and Discussion

Description of static pile composting techniques have been illustrated elsewhere (References #1, #7, and #8). The system at the canal has been developed using leaves, sawdust, compost and wood chips to absorb the liquid fraction of the waste and provide adequate pile aeration. Most recently, shredded paper from park offices has been successfully used as a bulking organic material. Sanitary waste averaged 2.5% solids while septage was about 1.7% solids. The ratio of bulking organics to waste is: 2 parts woodchips : 2 parts sawdust : 1 part compost for 3,785 liters (1,000 gal.) of waste (Table 1). This ratio may require modifications of bulking ratios due to climatic conditions or material availabilities within any geographic area. Other substitute materials could be equally effective. The topic of alternative bulking material is broad and requires extensive surveys of the local areas to evaluate "waste" organics. Many various organic materials may be quite functional within the composting system.

Raw wastes are highly variable with regard to their biological and chemical content (Table 2). Sanitary toilet waste from along the canal is primarily human excrement. As toilet facilities are pumped, a recharge of 18.9 liters (5 gallons) of water and about 150 ml of a disinfectant-deodorant are placed in each holding tank. The disinfectant was a zinc-based compound, and the sanitary waste data reflects this zinc loading. This material is being phased out and will eventually be replaced with formaldehyde. U.S. Forest Service scientists have been successfully using formaldehyde for several years. Formaldehyde, due to its chemical nature, is completely biodegradable within the composting system; a definite advantage over the present materials.

TABLE 1

BULKING MATERIALS USED FOR SANITARY WASTE

Waste Liters	Mattress (cu. m.)	Woodchips (cu. m.)	Sawdust (cu. m.)	Old Compost (cu. m.)	Blanket (cu. m.)
3,785	5.4	7.7	7.7	3.1	7.1
3,785	5.4	6.9	6.9	3.1	7.7
3,785	5.4	7.7	7.7	3.4	6.1

FOR SEPTAGE WASTE

Waste Liters	Mattress (cu. m.)	Woodchips (cu. m.)	Sawdust (cu. m.)	Old Compost (cu. m.)	Blanket (cu. m.)
4,731	5.4	7.7	7.7	3.1	7.7
3,785	5.4	6.9	6.9	3.1	15.3
3,785	5.4	7.7	7.7	3.4	12.2

TABLE 2

RAW WASTE DATA

Element	Sanitary			Septage		
	Range			Range		
	Max	Min	Mean*	Max	Min	Mean*
Coliform, MPN/g.	2,400.0	39.0	827.0	11,000.0	3.0	3,748.0
Total Coliforms, MPN/g.	2,400.0	3.0	814.0	4,600.0	3.0	1,571.0
Salmonella, + or -	neg.	neg.	neg.	neg.	neg.	neg.
Total Solids, %	2.8	2.1	2.5	2.4	1.1	1.7
Tot. Vol. Solids, %	2.0	0.9	1.3	1.5	0.7	1.0
BOD mg./l.	14,000.0	5,000.0	9,666.7	3,300.0	2,700.0	2,933.0
COD mg./l.	35,000.0	29,000.0	32,666.7	26,000.0	4,300.0	15,100.0
pH	8.0	7.7	8.0	6.5	5.9	6.1
Soluble Salts, ppm	3,340.0	3,240.0	3,297.0	525.0	135.0	278.3
Phosphorus, ppm	6,190.0	3,329.0	4,493.0	5,495.0	1,615.0	2,983.0
Potassium, ppm	3,911.0	2,965.0	3,312.0	305.0	80.5	158.5
TKN, ppm	186,400.0	142,700.0	160,130.0	22,960.0	6,720.0	13,293.0
Cd, ppm	2.2	1.1	1.5	2.3	1.5	1.8
Cu, ppm	602.0	30.0	226.0	827.0	40.0	516.3
Pb, ppm	43.0	18.0	31.0	103.0	33.0	62.7
Ni, ppm	8.0	6.0	7.0	16.0	9.0	12.3
Zn, ppm**	757.0	173.0	407.0	649.0	214.0	418.7

* These data points represent means collected across three composting replications.

** A zinc based disinfectant deodorant has been used in the toilet systems.

Septage waste is considerably more variable than sanitary waste, due to its origin. Household waste contains traces of compounds not found in human waste alone. Septage waste collected from different households vary due to the cleansers and other household chemicals used. Septic tanks are pumped at irregular frequencies; therefore, septage may have considerable time to chemically react under anerobic conditions.

Septage was delivered to the compost site in a tank truck and twin compost piles erected; one using sanitary waste, the other using septage. The only requirement placed upon the septage hauler was to deliver only household wastes. Data variations noted could be due to the septage from one or more septic tanks.

To evaluate the breakdown of the compost, periodic monitoring of both composting products was conducted by withdrawing samples from the pile using a sterilized auger and access pipes placed within the compost pile on the day it was erected. Access pipes projected to the outer level of the compost mixture and were capped. Blanket organics were placed over the entire pile and covered the capped pipes. At the end of the pipes, an engineer's flag was used to project through the blanket for easy location on sampling dates. Compost samples were withdrawn at intervals of one, two, three, and four weeks after the pile erection date for laboratory characterization. Microbiological data for this composting project is presented in a later paper of this section.

Data for the alteration of compost pH with time is presented in Figures 1 and 2. The pH values of the raw wastes were generally quite high and tended to drop off with composting time. Analysis of variance test for the change in the pH with time was statistically significant at the 0.01 level for sanitary compost, but not significant for septage compost, the respective correlation coefficients for pH alterations with compost time are $r = -0.95$ and $r = -0.85$ indicating good correlation. Final pH of 6.8 for sanitary compost and 6.9 for septage compost are fairly typical of composted products. The pH values for composted materials will vary but generally average 6.8. A value in this range is quite desirable for use in soil modification work; both for pH buffering and enhanced chelating of heavy metals which may be present.

Phosphorous levels within the composted products were quite low (Table 3). Sanitary compost averaged 0.29% and septic compost 0.25% phosphorous. Potassium levels are similar to phosphorous levels (Table 4) for both sanitary and septage composts, or 0.27% and 0.21% respectively.

Soluble salt contents were determined during composting and for the compost product (Table 5). This determination was conducted to provide a barometer for final product suitability for use around vegetation. Salt contents for sanitary waste appeared to be elevated by about a factor of two above septage compost. Analyses of variance for sanitary compost did not detect any significance with composting time. However, analyses of variance tests for septage compost with time was significant with time. SNK mean separation tests did not indicate any difference between mean salt contents. Sanitary waste compost had a soluble salt content of 1,598 ppm while the septage compost content was 880 ppm. Contents in this range could cause some problem for salt-sensitive plants unless proper blending soil materials is practiced. Compost soluble salt levels are characteristically high in fresh compost but

Figure 1

pH Distribution with Composting Time for Sanitary Material

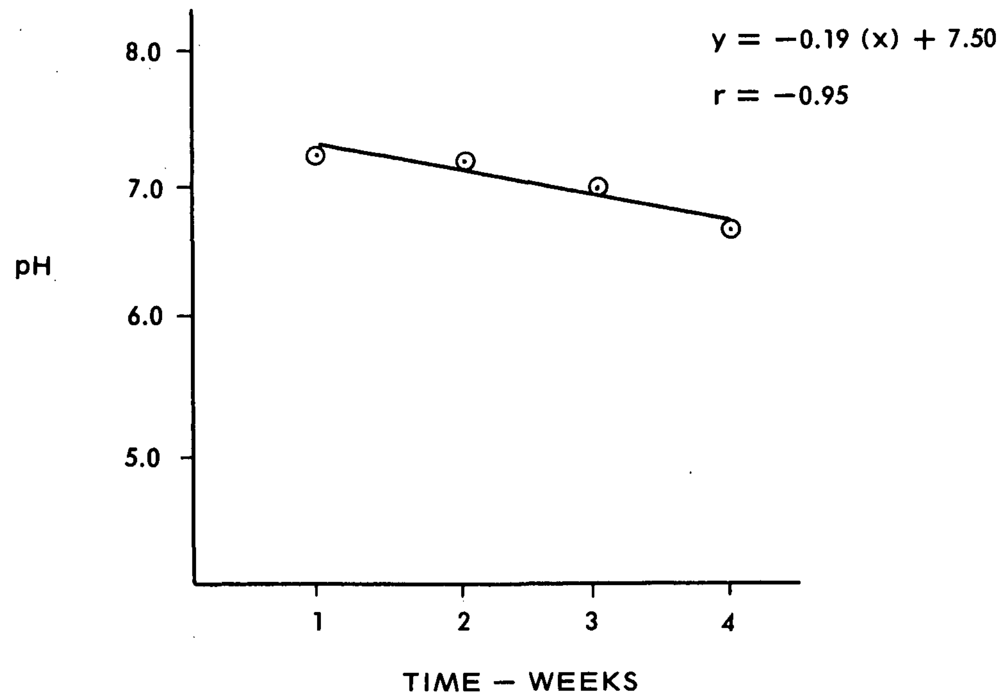

Figure 2

pH Distribution with Composting Time for Septage Material

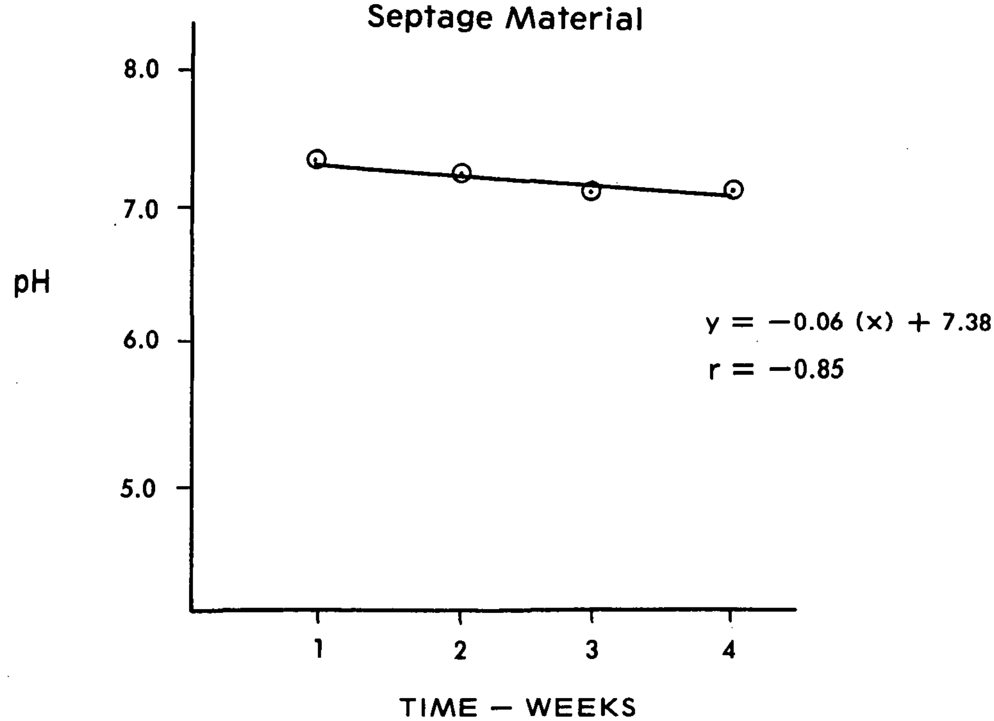

TABLE 3

PHOSPHOROUS ALTERATION WITH SAMPLING TIME
ppm

Sampling Interval	Sanitary Range Max	Sanitary Range Min	Sanitary X	Septage Range Max	Septage Range Min	Septage X
1 week	3,328	1,994	2,769.5 NS	3,228	1,557	2,247.3 NS
2 weeks	3,261	2,138	2,712.6 NS	3,193	1,609	2,245.4 NS
3 weeks	2,725	3,008	2,631.1 NS	3,067	1,732	2,231.4 NS
4 weeks	3,495	2,173	2,857.8 NS	2,842	1,857	2,224.2 NS

NS = Nonsignificant analysis of variance.

TABLE 4

POTASSIUM ALTERATION WITH SAMPLING TIME
ppm

Sampling Interval	Sanitary Range Max	Sanitary Range Min	Sanitary X	Septage Range Max	Septage Range Min	Septage X
1 week	2,894	1,637	2,180**b	2,792.0	985.0	1,644.8 NS a
2 weeks	7,565	1,380	3,114**ab	7,019.0	1,024.0	2,370.8 NS a
3 weeks	3,854	1,364	2,359**b	2,745.0	1,367.0	2,102.4 NS a
4 weeks	5,275	2,632	3,797**a	3,987.0	1,150.0	2,214.8 NS a

** - Analysis of variance significant at the 0.01 level.

- Letters within the mean column which are the same were not statistically different by Student, Newman, Keul test at the 0.05 level.

NS - Nonsignificant analysis of variance.

TABLE 5

SOLUBLE SALT ALTERATION WITH COMPOSTING TIME

Sampling Interval	Sanitary Range Max	Sanitary Range Min	Sanitary X	Septage Range Max	Septage Range Min	Septage X
1 week	2,200	850	1,261 NS	920	560	727.5**a
2 weeks	2,700	700	1,592 NS	1,200	500	791.7**a
3 weeks	1,540	820	1,433 NS	1,200	500	702.5**a
4 weeks	2,450	800	1,346 NS	1,400	580	800.8**a

NS - Nonsignificant analysis of variance.

** - Analysis of variance, significant at the 0.01 level.

a - Letters within the mean column which are the same were not statistically different by Student, Newman, Keul test at the 0.05 level.

TABLE 6

TOTAL KJELDAHL NITROGEN ALTERNATION WITH COMPOSTING TIME
ppm

Sampling Interval	Sanitary Range Max	Sanitary Range Min	Sanitary X	Septage Range Max	Septage Range Min	Septage X
1 week	9,100	5,060	6,583 NS	7,900	4,120	5,861 NS
2 weeks	9,680	6,030	7,782 NS	7,750	3,700	5,371 NS
3 weeks	12,820	500	8,143 NS	13,750	4,220	6,471 NS
4 weeks	9,730	5,510	7,708 NS	7,140	3,220	5,274 NS
Raw Waste	186,400	142,700	160,130	22,960	6,720	13,293
Compost	23,580	6,400	11,021	11,640	5,030	6,939

NS - Nonsignificant analysis of variance.

will generally be reduced with stockpiling time yielding a more stable product.

Total Kjeldahl nitrogen (TKN) levels were quite high for sanitary waste and rather low for septage: sanitary - 16.0% vs 1.3% for septage (Table 6). Presumably this difference is due to the relative exposure times to anerobic breakdown. Initial high TKN levels are important with regard to the amount of high carbon bulking material used. These nitrogen levels should provide an adequate nitrogen source for microbial activity within the compost piles, particularly the sanitary waste. Analysis of variance for both composting materials indicated no significant change with composting time.

Favorable microbial activity is indicated by the nitrate-nitrite -- ammonia curves (Figures 3 and 4). Analysis of variance tests did not detect any significance at the 0.01 level for either of these data arrays. However, these data do illustrate that microbial nitrogen transformations were occurring within the composting mixture.

Calculated correlation coefficients for sanitary compost ammonium alterations was a rather high $r = -0.76$ while the nitrate-nitrite nitrogen correlation was a very low $r = -0.11$. This latter coefficient reflects two data points which arbitrarily appear to be quite elevated - 107 ppm and 32 ppm; the range for the remaining ten observations was 1.03 ppm to 3.72 ppm. Due to the rapidity of nitrogen alteration within the compost medium, duplicate suspect observations were unable to be performed. However, should these suspect observations be deleted and/or presumed to fall within the observed data range, the resulting correlation coefficient is calculated to be $r = 0.88$.

A comparison of Figure 3 and 4 reflects an apparent difference between the nitrogen forms present within the two raw waste materials, perhaps due to their length of exposure to anaerobic degradation. Within the composting medium, the ammonium and nitrate-nitrite curves for both materials are the reverse of one another. Presumably within the raw waste materials, ammonium levels are high and nitrate-nitrite nitrogen levels are low for sanitary waste; the reverse is apparently true for septage due to its storage time under anaerobic conditions.

Analyses of the heavy metal levels within the raw wastes were higher than the levels found within the compost product with the exception of nickel and lead in sanitary compost and nickel in septic compost (Table 7). Cadmium levels were apparently higher but these differences could be due to background interference. Wastes collected from sanitary toilets contained lower metal levels than septage probably due to the differing sources of the wastes. Sanitary waste metal loadings were due principally to the human contribution; with the exception of zinc, a portion of which was added as an ingredient of the disinfectant-deodorant. Conversely, septage wastes are characteristic of differences experienced due to household loadings.

Ultimate use of either compost product poses little threat to environmental concerns when properly mixed with soils of the proper pH, cation exchange capacities, and organic matter contents. Composts generated from Park Service sites similiar to the canal's, will be utilized on recreational lands, physically disturbed or altered landscapes and other non-food chain linked land areas. Similarily, large areas of land within the Service could benefit from

Figure 3

Ammonium and Nitrate - Nitrite Nitrogen Distribution with Composting Time for Sanitary Compost

ppm

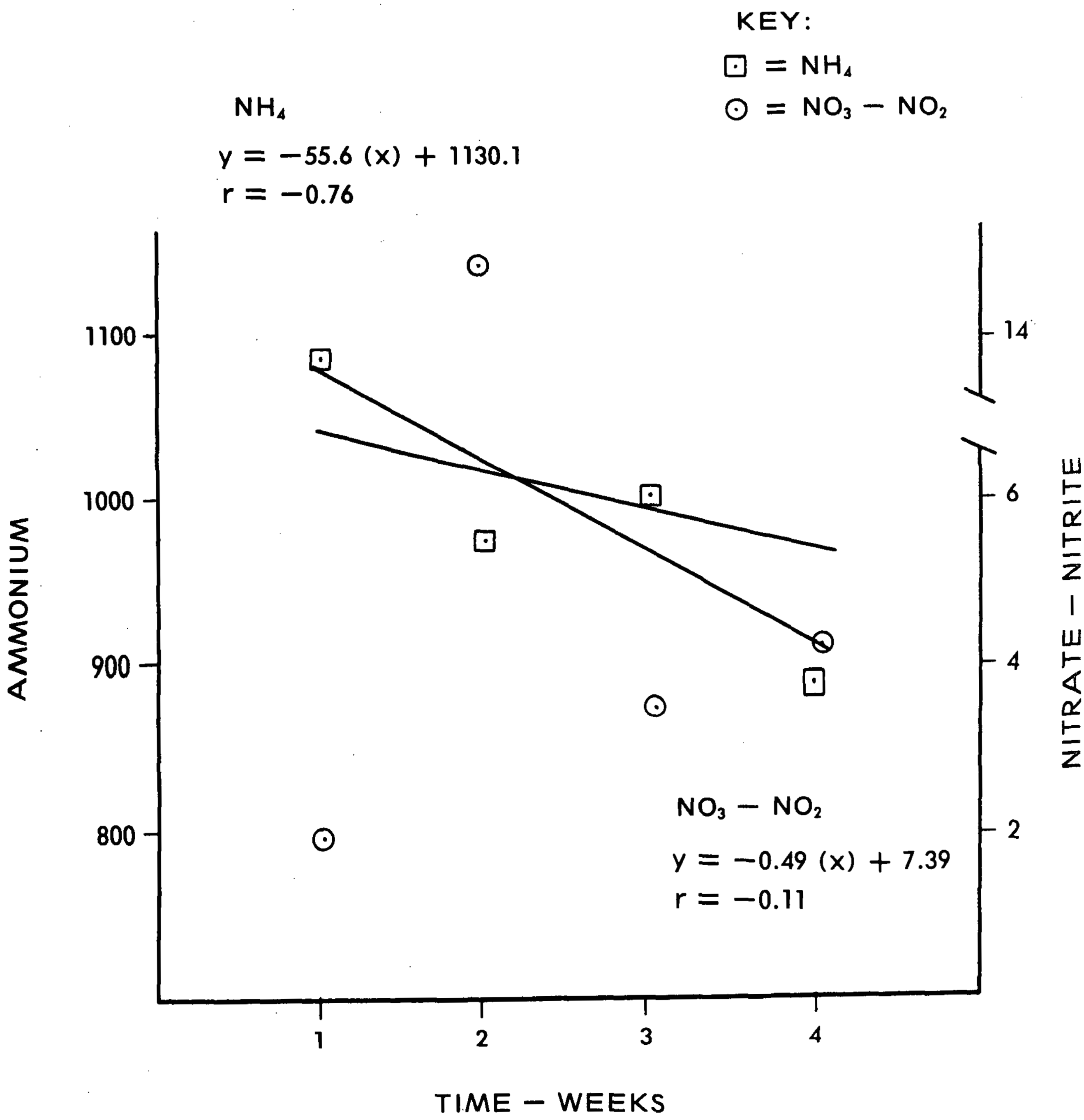

Figure 4

Ammonium and Nitrate - Nitrite Nitrogen Distribution with Composting Time for Septage Compost

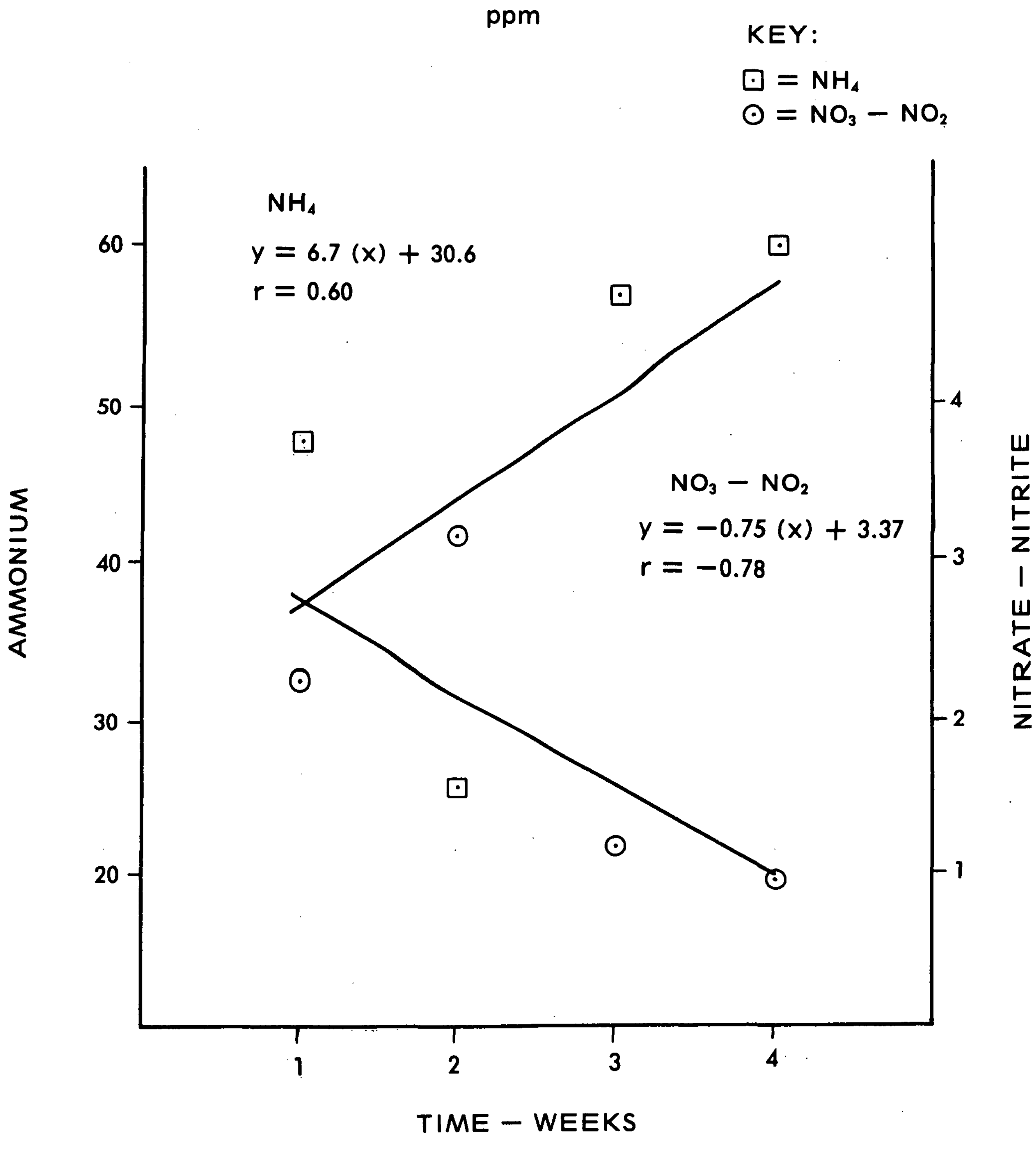

TABLE 7

HEAVY METAL ANALYSES FOR SANITARY AND SEPTIC COMPOSTS
ppm

	Sanitary			Septage		
	Range			Range		
Metal	Max	Min	X	Max	Min	X
Cd	3.2	2.8	3.0	3.2	1.1	2.5
Cu	61.0	44.0	50.0	214.0	54.0	90.8
Pb	88.0	62.0	70.0	75.0	32.0	58.6
Ni	34.0	22.0	28.0	38.0	19.0	26.5
Zn	247.0	189.0	217.0	242.0	149.0	189.8

applications of these composted materials and retreatment and/or metal loadings of any single site would be uncommon.

Table 8 presents the comparative data for both compost products. The pH levels of the products seems to indicate that these products would be desirable organic soil amendments for most soil renovation projects. Soluble salt contents indicate that stockpiling of the products would be desirable prior to any product utilization. Stockpiling would provide for some leaching of salts out of the compost and assist against any resultant damage to salt-sensitive plants when the product is utilized.

Experience has indicated that a stockpile time of 6 - 12 months is desirable. Stockpiling would reduce chances for re-contamination of the "sterile" compost product during the tearing down of the compost pile. USDA has noted that this regrowth of bacteria could be a problem due to the mixing of blanket materials with the compost. A stockpiling period allows a temperature build up into the thermal range which can cause a reduction in any bacterial regrowth. Work at the canal did not indicate that this was a problem, however.

Complete analysis has been made of the costs to treat the waste produced along the C & O Canal. Waste treatment for this area during the 1978 season cost the park approximately $.13/litre ($0.498/gal); this figure excludes a value for the final composted product which in the regional area sells for about $10 - $15/cu yd. When the value of the product is offset against treatment costs, the cost per gallon than becomes about $0.13. These costs appear quite high. However, when consideration is given to other available alternatives and their respective cost for tertiary treatment, these costs are much more reasonable. The real benefit is that wastes effectively receive tertiary treatment with virtually no environmental damage and a resource is generated.

Conclusion

Aerated static pile composting techniques can be successfully altered to thoroughly treat liquid human wastes. Several alternative processes have been cited. Static composting offers a workable cost effective alternative for sites remote from traditional treatment facilities, for sites which have severely limiting soil systems for leach fields, or areas which may not have funds to develop a sophisticated treatment plant and sewer pipe system such as the under developed countries.

Waste can be treated usually within a three to four week period; the system is highly adaptable for treatment of large or small volumes of waste; on site holding tanks can yield a more efficiently operating system; many, many different absorbant organic materials may be used as alternative bulking agents; compost products are nearly sterile organic materials which provide the site manager with a valuable soil conditioner which can be used to reduce the human impact on heavily visited sites; and very little energy and manpower are required to operate the onsite activities. If necessary, solar, wind or some other natural source can be used to charge storage batteries which in turn provide power for the operation of the on-site blower system. Although costs appear to be quite high per unit volume of waste, these costs can be significantly reduced by increasing the volumes of waste treated and altering some management patterns for any site.

TABLE 8

COMPARATIVE COMPOST DATA
ppm

Element	Sanitary			Septage		
	Range			Range		
	Max	Min	Mean	Max	Min	Mean
Coliform, MPN/g	3.00	3.00	3.00	3.00	3.00	3.00
Fecal Coliform, MPN/g	3.00	3.00	3.00	3.00	3.00	3.00
Salmonella	neg.	neg.	neg.	neg.	neg.	neg.
Total Solids, %	56.70	38.20	47.60	59.60	43.40	52.70
Total Volatile Solids, %	19.90	18.20	19.20	19.20	15.80	17.60
pH	7.45	5.76	6.83	7.34	6.34	6.90
Soluble Salts, ppm	2,500.00	880.00	1,598.00	1,370.00	600.00	880.00
Phosphorous, ppm	3,765.00	2,173.00	2,871.00	2,894.00	2,115.00	2,460.00
Potassium, ppm	4,012.00	1,774.00	2,690.00	3,673.00	1,409.00	2,092.00
TKN, ppm	23,580.00	6,400.00	11,021.00	11,640.00	5,030.00	6,939.00
NH_4, ppm	1,826.00	18.00	885.00	201.50	31.70	120.60
NO_3 - NO_2, ppm	3.01	0.18	1.99	1.86	0.30	2.75
Cd, ppm	3.20	2.80	3.00	3.20	1.10	2.50
Cu, ppm	61.00	44.00	50.00	214.00	54.00	90.80
Pb, ppm	88.00	62.00	70.00	46.00	32.00	58.60
Ni, ppm	34.00	22.00	28.00	38.00	19.00	26.50
Zn, ppm	247.00	189.00	217.00	242.00	149.00	189.80

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Appendix C

California Regional Water Quality Control Board
North Coast Region

ORDER NO. 81-25

WASTE DISCHARGE REQUIREMENTS

for

U.S.D.I. REDWOOD NATIONAL PARK
WOLF CREEK COMPOST FACILITY

Humboldt County

The California Regional Water Quality Control Board, North Coast Region, finds that:

1. The U.S.D.I., Redwood National Park (hereafter the discharger) submitted a complete report of waste discharge dated January 9, 1981, describing a static pile composting facility at the Wolf Creek yard located in Section 10, T11N, R1E, HB & M as shown on Attachment A incorporated herein.

2. The proposed facility will utilize a forced air/static pile system to provide thermophylic composting of chemical toilet waste, septage, and holding tank waste with sawdust, wood chips, and shredded office paper. The finished product will be used as a soil amendment in the Park's watershed rehabilitation program on lands tributary to Redwood Creek as specified herein. Waste volumes are estimated at less than 23,000 gallons per year requiring less than 10 acres per year for disposal.

3. Thermophylic composting is an effective means of disinfecting sewage sludge and similar wastes. The possibility of limited pathogen survival necessitates restricted use of the finished compost. Use of finished compost as specified herein effectively prevents the discharge of compost to surface waters and associated public health problems.

4. The Regional Board adopted the Water Quality Control Plan for the North Coastal Basin on March 20, 1975, and amended the Plan on March 25, 1976. The Plan contains water quality objectives for Redwood Creek.

5. As enumerated in the Water Quality Control Plan, beneficial uses of Redwood Creek and its tributaries include:

   a. municipal, agricultural, and industrial water supply
   b. groundwater recharge
   c. water contact and non-water contact recreation
   d. warm and cold freshwater habitat
   e. wildlife habitat
   f. preservation of rare and endangered species
   g. fish migration and spawning

6. The Board has notified the discharger and interested agencies and persons of its intent to prescribe Waste Discharge Requirements for the proposed discharge and has provided them with an opportunity for a public hearing and an opportunity to submit their written views and recommendations.

7. The Board, in a public meeting, heard and considered all comments pertaining to the discharge.

8. Pursuant to the National Environmental Protection Act, a Finding of No Significant Impact was prepared and filed on September 12, 1980. The Regional Board finds that this project will not have adverse effects on water quality if conducted in conformance with the terms of this order.

9. All waste treatment and disposal facilities shall be installed in accordance with plans and specifications submitted to and approved by the Executive Officer.

THEREFORE, IT IS HEREBY ORDERED that the discharger shall comply with the following:

A. DISCHARGE SPECIFICATIONS:

1. No finished compost material shall be applied to land unless monitoring records indicate that temperatures in excess of 55°C were maintained for a period of five days.

2. The finished compost material shall be stabilized for a period of at least six months after active composting and before it is applied to land.

3. All storage, mixing, and composting of wastes shall be performed on impermeable surfaces to collect and prevent the discharge of any leachate. All finished product and waste storage facilities shall be covered to prevent the creation of leachate.

4. All active composting and mixing facilities as well as finished product and raw materials storage facilities shall be protected from stormwater flows from rainfall events having a 25 year frequency.

5. No uncovered composting operations shall be performed during the period from October 1st until the following May 1st.

6. An operation and maintenance manual for the proposed composting operation shall be submitted to and approved by the Executive Officer prior to starting composting operations.

7. Land application of finished compost shall be confined to sites approved by the Executive Officer as meeting the following criteria:

   a. There shall be no land application of compost to land not controlled by the discharger.

   b. There shall be no land application of compost in areas where slope steepness exceeds 10 percent, in areas where springs or marshy conditions are known to exist, nor in areas prone to gully erosion or soil mass movement.

   c. There shall be no land application of compost in areas where less than a 100 foot buffer zone of healthy vegetation exists between the compost and any surface waters or ephemeral drainages.

   d. There shall be no land application of compost in areas where access by the public is not controlled by the discharger to prevent public contact.

8. All finished compost shall be worked into the soil in a manner subject to the approval of the Executive Officer. All areas which receive compost shall be seeded, stabilized, and protected from erosion and washout prior to October 1st of each year and subject to the approval of the Executive Officer.

9. The discharge of finished compost, raw materials, or wastes to surface waters is prohibited.

B. PROVISIONS:

1. All waste treatment and disposal facilities shall be installed according to applicable ordinances of the Humboldt County Health Department.

2. The discharger shall comply with the Monitoring and Reporting Program No. 81-25 and Contingency Planning and Notification Requirements No. 74-151 and any modifications to this document as specified by the Executive Officer. Such document is attached to this order and incorporated herein.

3. Neither the treatment nor disposal of wastes shall cause a pollution or nuisance as defined in Section 13050 of the California Water Code.

4. This Board requires the discharger to file a report of waste discharge at least 120 days before making any material change or proposed change in the character, location or volume of the discharge.

5. In the event the discharger is unable to comply with any of the conditions of this order due to:

a. breakdown of waste treatment equipment;
b. accidents caused by human error or negligence; or
c. other causes, such as acts of nature;

the discharger shall notify the Executive Officer by telephone as soon as he or his agents have knowledge of the incident and confirm this notification in writing within two weeks of the telephone notification. The written notification shall include pertinent information explaining reasons for the noncompliance and shall indicate what steps are being taken to prevent the problem from recurring.

6. The discharger shall permit the Regional Board:

   a. entry upon premises in which an effluent source is located or in which any required records are kept;
   b. access to copy any records required to be kept under terms and conditions of this order;
   c. inspection of monitoring equipment or records; and
   d. sampling of any discharge.

7. The discharger shall maintain in good working order and operate as efficiently as possible any facility or control system installed by the discharger to achieve compliance with the waste discharge requirements.

8. In the event of any change in control or ownership of land or waste discharge facilities presently owned or controlled by the discharger, the discharger shall notify the succeeding owner or operator of the existence of this order by letter, a copy of which shall be forwarded to this Board.

9. The discharger shall notify Regional Board staff at least two weeks prior to anticipated application of compost to land.

Certification

I, David C. Joseph, Executive Officer, do hereby certify that the foregoing is a full, true, and correct copy of an order adopted by the California Regional Water Quality Control Board, North Coast Region, on January 22, 1981.

David C. Joseph
Executive Officer

California Regional Water Quality Control Board
North Coast Region

CONTINGENCY PLANNING AND NOTIFICATION REQUIREMENTS FOR ACCIDENTAL SPILLS & DISCHARGES

ORDER NO. 74-151

The California Regional Water Quality Control Board, North Coast Region, finds that:

1. Section 13225 of the Porter-Cologne Water Quality Control Act requires the Regional Board to perform general duties to assure positive water quality control.

2. The Regional Board has been advised of situations in which preparation for, and response to accidental discharges and spills have been inadequate.

3. Persons discharging waste or conveying, supplying, storing or managing wastes or hazardous materials have the primary responsibility for contingency planning, incident reporting and continuous and diligent action to abate the effects of such unintentional or accidental discharge.

THEREFORE, IT IS HEREBY ORDERED THAT:

I. All persons who discharge wastes or convey, supply, store or otherwise manage wastes or other hazardous material shall:

A. Prepare and submit to this Regional Board, according to a time schedule prescribed by the Executive Officer, a contingency plan defining the following:

(1) potential locations and/or circumstances under which accidental discharge incidents might be expected to occur,

(2) possible water quality effects of accidental discharges,

(3) the conceptual plan for cleanup and abatement of accidental discharge incidents, including:

(a) the individual who will be in charge of cleanup and abatement activities, on behalf of the discharger,

(b) the equipment and manpower available to the discharger to implement the cleanup and abatement plans.

B. Immediately report to the Regional Board any accidental discharge incidents. Such notification shall be made by telephone as soon as the responsible person or his agent has knowledge of the incident.

C. Immediately begin diligent and continuous action to cleanup and abate the effects of any unintentional or accidental discharge. Such actions shall include temporary measures to abate the discharge prior to completing permanent repairs to damaged facilities.

D. Confirm the telephone notification in writing within two weeks of the telephone notification. The written notification shall include: reasons for the discharge, duration and volume of the discharge, steps taken to correct the problem, and steps being taken to prevent the problem from recurring.

II. Upon original receipt of phone report (I.B), the Executive Officer shall immediately notify all affected agencies and known users of waters affected by the unintentional or accidental discharge.

III. Provide updated information to the Regional Board in the event of change of staff, size of the facility, or change of operating procedures which will affect the previously established contingency plan.

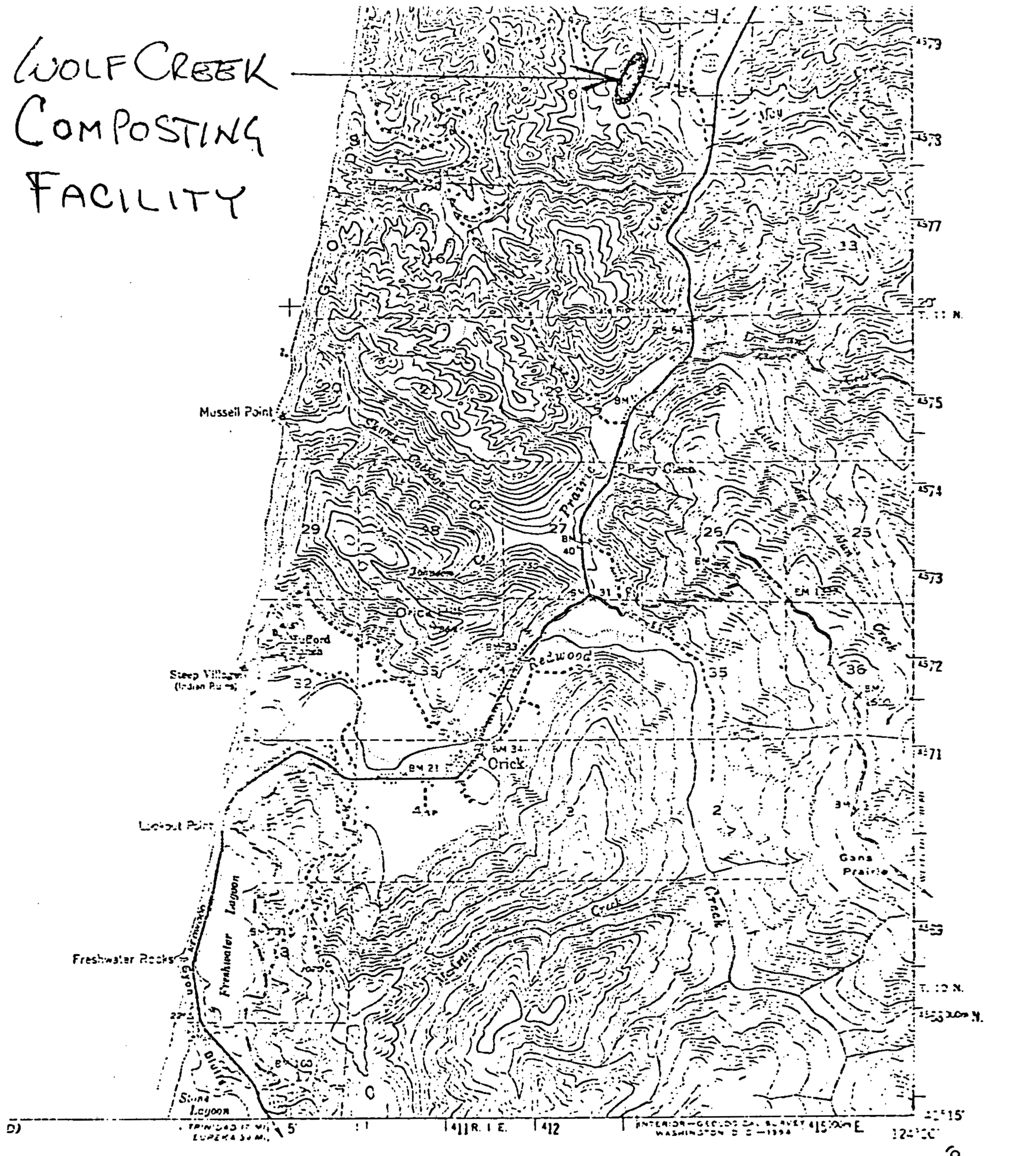
IV. The Executive Officer or his employees shall maintain liaison with the discharger and other affected agencies and persons to provide assistance in cleanup and abatement activities.

V. The Executive Officer shall transmit copies of this order to all persons whose discharges or waste handling activities are governed by Waste Discharge Requirements or an NPDES Permit. Such transmittal shall include a current listing of telephone numbers of the Executive Officer and his key employees to facilitate compliance with Item I.A(3)(a) of this Order.

Ordered by ______________________
David C. Joseph
Executive Officer

July 24, 1974

WOLF CREEK COMPOSTING FACILITY



ROAD CLASSIFICATION

Heavy-duty — Light-duty

Medium-duty — Unimproved dirt

U. S. Route

QUADRANGLE LOCATION

ORICK, CALIF.

1952

R 25, COLORADO OR WASHINGTON 25, D. C.

AMS 1352 I-SERIES V795

ATTACHMENT "A"

California Regional Water Quality Control Board
North Coast Region

MONITORING AND REPORTING PROGRAM NO. 81-25

for

U.S.D.I. REDWOOD NATIONAL PARK
WOLF CREEK COMPOST FACILITY

Humboldt County

MONITORING

I. Composting Operations

a. Each compost pile shall be monitored every three days for temperature and oxygen at ten locations distributed evenly throughout the pile.

b. Two composite samples shall be taken from each compost pile after active compositing is complete and analyzed for total coliform, fecal coliform and fecal streptococcus. Each composite sample shall be composited from samples taken at four locations distributed evenly throughout the pile.

II. Land Applications

a. Each land application site shall be monitored for total nitrogen (TKN + NO_3 + NO_2) and coliform bacteria above and below the site. Samples of stormwater runoff shall be taken above the site and below the site twice monthly during the period from October 1st to May 1st of the following year. Samples shall be collected during rainfall events at locations to be determined and approved by the Executive Officer when the sites are approved for land application.

REPORTING

Monitoring reports shall be submitted to the Regional Board monthly by the 15th day of the following month. In reporting the monitoring data, the discharger shall arrange the data in tabular form so that the date, the constituents, and the concentrations are readily discernible. Each monthly report shall include a narrative prepared by the system operator containing the following information:

1. A written record shall be kept for each pile including the date of constructing the pile, any dates of remixing the pile, the date of dismantling the pile, and a narrative of operator observations regarding the pile. The narrative shall include any problems with the aeration system, odors, vectors, or maintenance of proper temperatures and oxygen supply in the pile, in addition to a description of the source, type, and quantity of both wastes and bulking agents used in each pile.

2. A written record shall be kept regarding the date, source, types, and quantities of wastes and bulking agents received at the facility. Any problems related to odors or insect/rodent vectors shall be noted.

3. A written record shall be kept regarding storage and stabilization of the finished compost product including the beginning and ending dates of compost stabilization and any vector or odor problems noted during storage.

4. A written record shall be kept regarding land application of finished compost including dates of application, a description of the methods of application, location of application, and the estimated volume of compost applied at each location. When reporting monitoring results of stormwater sampling above and below land application sites, the amount of precipitation shall be recorded.

The monitoring and any necessary narrative reports shall be transmitted in accordance with specifications of Resolution No. 71-5 adopted by the Board on February 3, 1971.

Ordered by David C. Joseph

David C. Joseph
Executive Officer

January 22, 1981

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
NORTH COAST REGION

GENERAL MONITORING AND REPORTING PROVISIONS

February 3, 1971

GENERAL PROVISIONS FOR SAMPLING AND ANALYSIS

Unless otherwise noted, all sampling, sample preservation, and analyses shall be conducted in accordance with the current edition of "Standard Methods for the Examination of Water and Waste Water" or approved by the Executive Officer.

All analyses shall be performed in a laboratory certified to perform such analyses by the California State Department of Health or a laboratory approved by the Executive Officer.

All samples shall be representative of the waste discharge under the conditions of peak load.

GENERAL PROVISIONS FOR REPORTING

For every item where the requirements are not met, the discharger shall submit a statement of the actions undertaken or proposed which will bring the discharge into full compliance with requirements at the earliest time and submit a timetable for correction.

By January 30 of each year, the discharger shall submit an annual report to the regional board. The report shall contain both tabular and graphical summaries of the monitoring data obtained during the previous year. In addition, the discharger shall discuss the compliance record and the corrective actions taken or planned which may be needed to bring the discharge into full compliance with the waste discharge requirements.

The discharger shall file a written report within 90 days after the average dry-weather flow for any month that equals or exceeds 75% of the design capacity of the waste treatment or disposal facilities. The report shall contain a schedule for studies, design, and other steps needed to provide additional capacity or limit the flow below the design capacity prior to the time when the waste flow rate equals the capacity of the present units.

STATE OF CALIFORNIA—RESOURCES AGENCY

EDMUND G. BROWN JR., Governor

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD— NORTH COAST REGION

1000 CODDINGTOWN CENTER
SANTA ROSA, CALIFORNIA 95401
Phone: 707—545-2620

June 25, 1981

Mr. Robert D. Barbee
Superintendent
Redwood National Park
111 Second Street
Crescent City, CA 95531

Dear Mr. Barbee:

Thank you for providing us with a copy of the Operation and Maintenance Manual for the Wolf Creek Compost Facility dated June 1981. Our review of this document indicates that your staff has done a thorough and professional job in preparing the manual. We do, however, have several comments relating to your project.

1. The section entitled "Emergency Procedures" should include our phone number (707) 545-2620, that of the Humboldt County Health Department and those of any downstream water users. Also, if spills less than 20 gallons occur involving discharge to surface waters, the same emergency procedures as for larger spills should be implemented.

2. Both the Introduction and Table A make reference to uses of finished compost material which would constitute a violation of waste discharge requirements (i.e., use on hiking trails to control compaction and use on vegetables, legumes, etc.). The manual should clearly state that land application sites are to be approved by the Regional Board Executive Officer prior to use.

3. It is our understanding that the water supply system for the compost facility uses the same well as the nearby Humboldt County School Camp. Please be informed that an air gap system or a backflow prevention device which is acceptable to the Humboldt County Health Department must be installed to protect this well.

Provided that the above considerations are incorporated in your Operations and Maintenance Manual, we find your report to be satisfactory under Discharge Specification A.6. We wish you success in your project and if you have further questions of this office, do not hesitate to call.

Sincerely,

David C. Joseph
Executive Officer

cc: Humboldt County Health Department

JUN 2 9 1981

GPO 590-577/406