EPA-600/2-78-078
April 1978

Environmental Protection Technology Series

ALTERNATE METHODS OF MANURE HANDLING

Robert S. Kerr Environmental Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Ada, Oklahoma 74820

Regional Center for Environmental Information
US EPA Region III
1650 Arch St.
Philadelphia, PA 19103

RESEARCH REPORTING SERIES

Research reports of the Office of Research and Development, U.S. En Protection Agency, have been grouped into nine series. These nine gories were established to facilitate further development and applic vironmental technology. Elimination of traditional grouping was consciously planned to foster technology transfer and a maximum interface in related fields. The nine series are:

1. Environmental Health Effects Research
2. Environmental Protection Technology
3. Ecological Research
4. Environmental Monitoring
5. Socioeconomic Environmental Studies
6. Scientific and Technical Assessment Reports (STAR)
7. Interagency Energy-Environment Research and Development
8. "Special" Reports
9. Miscellaneous Reports

This report has been assigned to the ENVIRONMENTAL PROTECTION TECHNOLOGY series. This series describes research performed to develop and demonstrate instrumentation, equipment, and methodology to repair or prevent environmental degradation from point and non-point sources of pollution. This work provides the new or improved technology required for the control and treatment of pollution sources to meet environmental quality standards.

This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

EPA-600/2-78-078
April 1978

ALTERNATE METHODS OF MANURE HANDLING

by

Frederick R. Magdoff
Grant D. Wells
Arthur E. Smith
Steven Goldberg
John Amadon
Agricultural Experiment Station
University of Vermont
Burlington, Vermont 05401

Grant No. R-803883

Project Officer

Lynn R. Shuyler
Source Management Branch
Robert S. Kerr Environmental Research Laboratory
Ada, Oklahoma 74820

ROBERT S. KERR ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
ADA, OKLAHOMA 74820

DISCLAIMER

This report has been reviewed by the Robert S. Kerr Environmental Research Laboratory, U.S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

FOREWORD

The Environmental Protection Agency was established to coordinate administration of the major Federal programs designed to protect the quality of our environment.

An important part of the Agency's endeavors to fulfill its mission involves the search for information about environmental problems, management techniques and new technologies through which optimum use of the nation's land and water resources can be assured. The primary and ultimate goal of these efforts is to protect the nation from the scourge of existing and potential pollution from all sources.

EPA's Office of Research and Development conducts this search through a nationwide network of research facilities.

As one of these facilities, the Robert S. Kerr Environmental Research Laboratory is responsible for the management of programs to: (a) investigate the nature, transport, fate and management of pollutants in groundwater; (b) develop and demonstrate methods for treating wastewaters with soil and other natural systems; (c) develop and demonstrate pollution control technologies for irrigation return flows; (d) develop and demonstrate pollution control technologies for animal production wastes; (e) develop and demonstrate technologies to prevent, control or abate pollution from the petroleum refining and petrochemical industries; and (f) develop and demonstrate technologies to manage pollution resulting from combinations of industrial wastewaters or industrial/municipal wastewaters.

This report is a contribution to the Agency's overall effort in fulfilling its mission to improve and protect the nation's environment for the benefit of the American public.

William C. Galegar

William C. Galegar, Director
Robert S. Kerr Environmental
Research Laboratory

ABSTRACT

The objectives of this research project were to (a) construct an inexpensive storage facility for solid dairy cow manure, (b) evaluate its performance and the extent of pollutants in runoff from storage facilities, and (c) determine current manure handling practices in Vermont and dairy farmers' attitudes and expectations with regard to possible future regulations on manure handling.

A storage facility was constructed at the University of Vermont (UVM), Animal Sciences Research Center (Spear Street Farm) and runoff from the site was channeled through sampling huts. A second site was established on a dairy farm in North Hero, Vermont. Runoff from the stacked manure was sampled weekly.

The quality and quantity of runoff from the storage sites indicate a substantial potential to pollute. Runoff from open stacks of manure should, therefore, be contained in a lagoon and irrigated on cropland. Alternately, runoff could be eliminated by covering the manure.

A survey of Vermont commercial dairy farmers (20 or more milking cows) indicated that most felt they could not afford the cost of changing manure handling systems. Only 3 percent of all dairymen definitely intended to change manure handling systems. However, most felt that saving the fertilizer value of manure would be a more important reason for them to change systems than would be reduced chore time.

This report was submitted in fulfillment of Grant No. R803883 by the University of Vermont under the partial sponsorship of the U.S. Environmental Protection Agency. This report covers a period from September 1974 to June 1977, and work was completed as of June, 1977.

CONTENTS

FIGURES

TABLES

SECTION 1

INTRODUCTION

The traditional method to dispose of dairy cow manure from stanchion barns in the Northeast has been to daily haul and spread the manure on fields. This practice is still prevalent in many parts of the region. Studies have demonstrated that when manure is applied on frozen or snow-covered soil during the winter months, substantial nutrient losses can occur with field runoff (5, 6, 7). Much of the nutrient loss from manure application on frozen or snow-covered ground is associated with applying manure during a thaw (6) or when a thaw and rainfall occur soon after manure application (5). However, manure applied to frozen soil in plots that have been rough plowed may actually decrease runoff volume and soil loss (10).

Concern over winter spreading of manure, because of the loss of its fertilizer value as well as the associated pollution of surface waters, has led to renewed interest in long-term (6 months or more) manure storage. Seepage from stacked manure can contain large amounts of various plant nutrients, solids, and COD (3, 9). Concrete and steel structures that contain manure completely are available, but their high cost makes them unattractive to the low-to-medium-income farmer. An inexpensive manure storage facility for stanchion barn manure was, therefore, constructed and monitored to evaluate its performance. A second conventional manure stack was also monitored.

In addition, Vermont dairyment were surveyed to determine their current manure handling practices as well as their attitudes towards changing manure handling systems.

SECTION 2

CONCLUSIONS

The concentrations and amounts of nutrients in runoff from the manure storage facility were high enough to cause deterioration of water quality in small streams and ponds. Consequently, substantial fertility value was lost during manure storage. The runoff from such a facility should be confined in a lagoon and irrigated on cropland, or the manure stack should be covered to eliminate the large volume of contaminated runoff. Covering for the facility should probably be a permanent roof rather than a thin plastic sheet placed directly on the pile. The latter is cumbersome and not very efficient. Using a lagoon with a manure stack involves both solid and liquid waste handling. However, this may prove necessary for most dairy farms with stanchion barns anyway in order to handle both manure and milking center wastes. The large amount of bedding used with stanchion barn manure indicates that the manure will probably continue to be handled mainly in the solid or semisolid state.

Most Vermont dairy farmers answering the questionnaire felt that saving the fertility value of the manure was a better reason to change manure handling practices than possible reduced chore time. Few farmers felt that they could afford the cost of changing to new manure handling systems.

SECTION 3

RECOMMENDATIONS

The relatively inexpensive facility for storing manure from stanchion barns was easy to manage. However, runoff from an uncovered facility in humid regions certainly has the potential to pollute. It is therefore strongly suggested that either the manure storage area be covered or the runoff contained in a lagoon and later irrigated on cropland. If the manure is covered, a permanent roof is much superior to a plastic covering.

The farmer survey indicates that if inexpensive solutions to manure storage are not found or if a costly structure cannot be subsidized, resistance to regulations dealing with manure storage may be expected.

The survey also indicated that greater farmer knowledge of the fertility losses during their current practices (mainly daily spreading) might help convince them of the benefits of newer manure handling systems.

SECTION 4

MATERIALS AND METHODS

UNIVERSITY OF VERMONT FARM RUNOFF SITE CONSTRUCTION AND MONITORING INSTALLATIONS

The 18 x 50 m manure storage facility was constructed at the University of Vermont (UVM) Animal Sciences Research Center (Spear Street Farm) so that all seepage and stack runoff would flow to the two low corners (Figure 1). The sod was stripped and the natural contour was graded to provide a 2% to 5% slope toward the outlet. The side that sloped towards monitoring hut 1, (site 1, 18 x 26 m storage area) was constructed as follows: the base consisted of 10 to 15 cm of crusher run gravel, a 0.15-mm thick plastic sheet protected by 2 to 5 cm of fines above and below to prevent puncture, and 8 to 10 cm of crushed limestone (passing a 1.9-cm screen) on the surface (Figure 2). The base of the side that sloped toward monitoring hut 2 (site 2, 18 x 24 m) consisted of 20 cm of either 1.9 cm or 3.8 cm diameter peastone. A treated plastic plank and post wall, covered with plastic, was constructed along the rear of the facility to prevent manure from slumping out of the storage area. Manure was stacked from the rear of a conventional box manure spreader to a height of about 1.2 m. A picket fence dam was constructed to retain large solids within the stacking area while allowing liquid and small particulates to flow to the monitoring stations from the low corner of the facility. A lagoon, collecting all runoff from the site, was emptied by irrigation onto corn fields.

A tipping-bucket mechanism was installed in the monitoring stations to obtain a flow-composite sample of the runoff. Runoff volume was recorded by attaching a counter to the tipping bucket. During monitoring of individual peak runoff events, a flow recorder and automatic sampler were used instead of the tipping bucket apparatus. Precipitation and temperature were monitored with a recording rain gauge and a recording thermometer respectively.

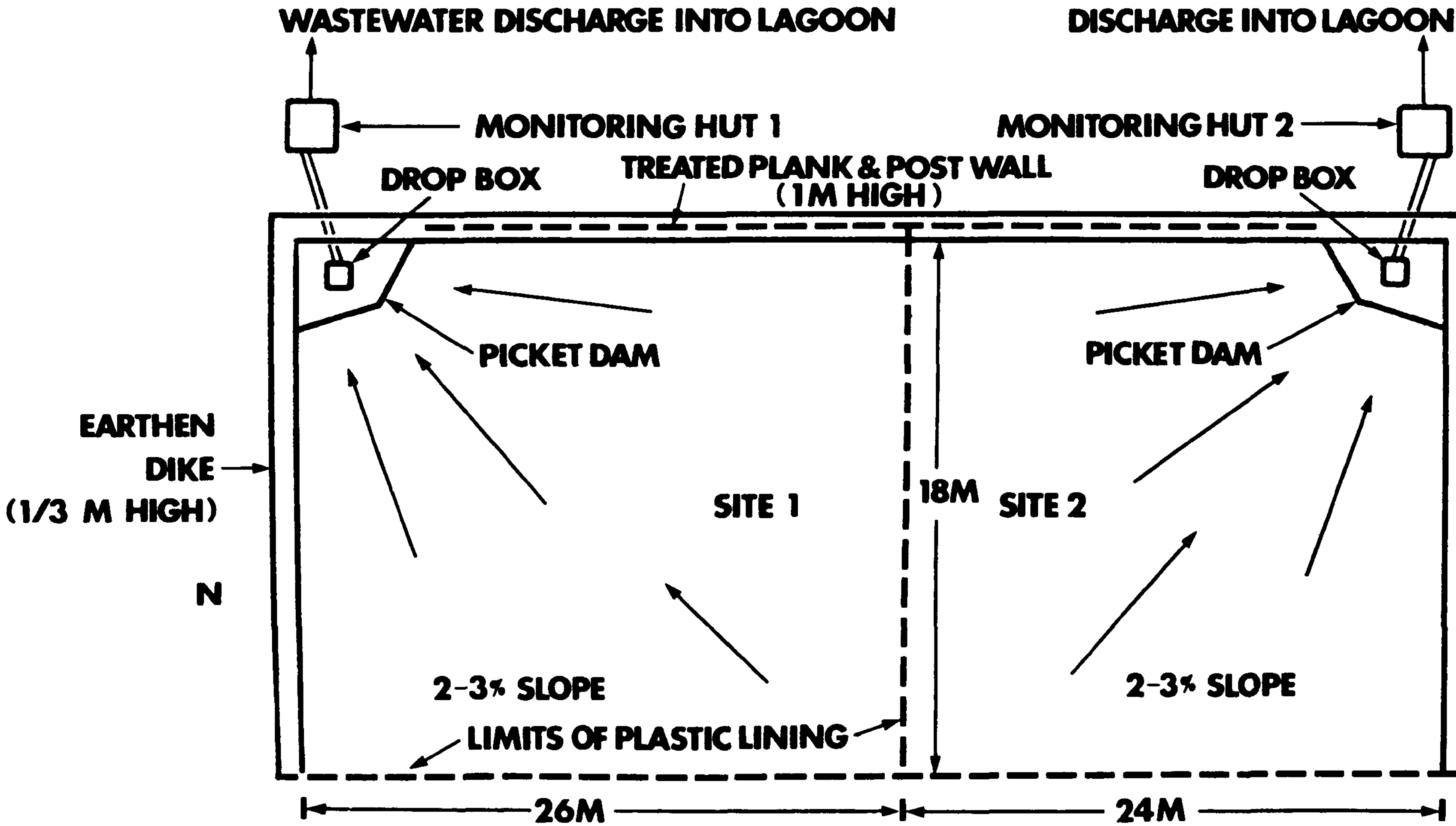

Figure 1. Design of manure storage facility at UVM Spear Street Farm.

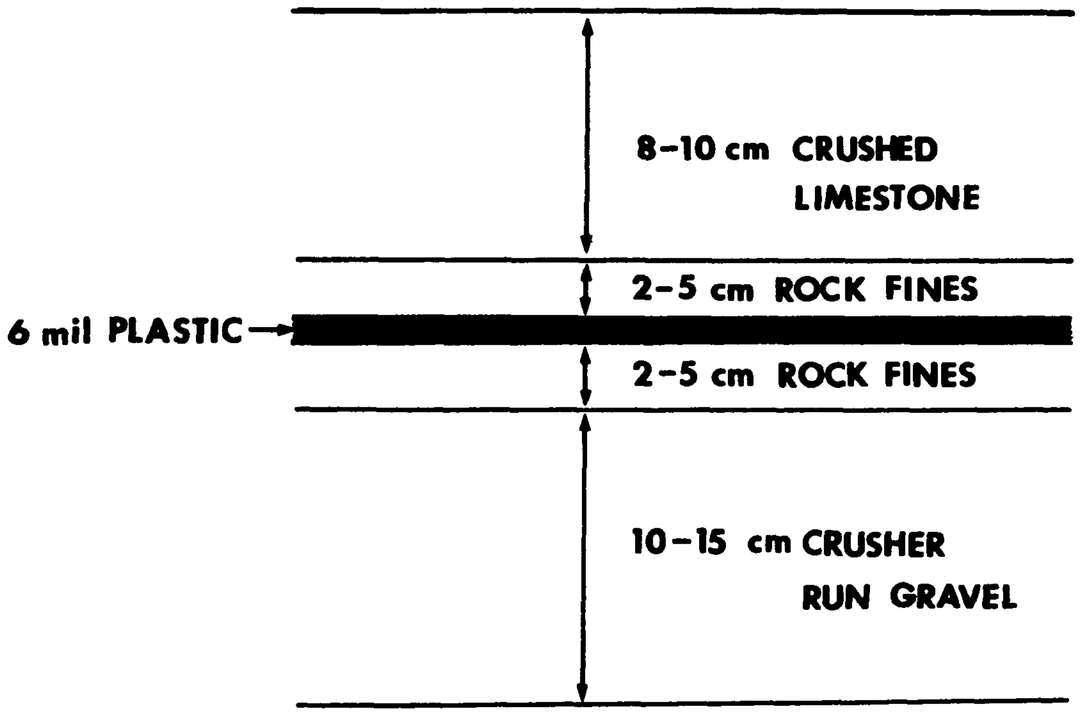

Figure 2. Diagram of cross-section of base of site 1 at UVM Spear Street Farm.

The basic cost for both sites of the storage facility (excluding research-related features and equipment for handling manure and the liquid runoff) was $2,600. This was $40 per cow at the UVM Spear Street Farm.

Manure containing sawdust bedding from the 62-cow stanchion barn at the UVM Spear Street Farm was stacked in the storage facility from January until May 4, 1975 (UVM site 1). After unloading and spreading, manure was brought to the site daily and stored again from May 14 until November 4 when it was unloaded. Manure was stored at the site from January 2, 1976, through May 10, 1976, when it was again unloaded. Manure was brought to the site from July 7, 1976 to December 22, 1976 and stored until unloaded April 28, 1977. During this last time interval manure stored at UVM site 1 was covered with black plastic. Site 2 received small quantities of manure from August 15, 1975 through September 15, 1975. The manure was unloaded November 4, 1975. Manure was stored again from January 2, 1976 through May 10, 1976 when it was again unloaded. Manure was brought to the site again from December 22, 1976 through March 31, 1977 and was unloaded April 28, 1977. During this last storage period site 2 was left uncovered while manure at site 1 was covered with black plastic (see above). After each unloading a residual of manure mixed with gravel and some manure along the sides remained.

During the first unloading there were isolated areas of sponginess in the base and care had to be taken to avoid tearing the plastic lining. However, the well-graded material in the limestone base compacted after the first unloading and allowed easy operation of wheeled tractors. Average manure characteristics during 1975, 1976, and 1977 are presented in Table 1.

Monitoring at UVM site 1 was carried out for the entire period January 1975 through April 1977 whether or not manure was stored at the site. Monitoring of UVM site 2 began August 1975 and lasted until April 1977.

NORTH HERO FARM

Another manure runoff site was established in Grande Isle County behind the dairy barn of a commercial farmer. The stacking area (about 21 x 21 m) was surrounded by low earthen dikes and the entire area covered with a 6-mil black sheet plastic. Runoff was directed to a shallow sump containing a float-controlled submersible pump. Runoff samples were taken from the sump weekly and the flow was estimated by recording pump operation time.

TABLE 1. AVERAGE MANURE CHARACTERISTICS WHEN BROUGHT TO UVM SITE

Characteristic	Year		
% (dry wt. basis)	1975*	1976+	1977#
NH_4-N	0.65	0.90	0.98
Total-N	2.19	2.65	2.69
P	0.50	0.54	0.64
K	1.50	1.41	1.47
Ca	2.37	4.14	4.80
Mg	0.42	0.48	0.63
Na	0.42	0.38	0.53
Dry wt. (% of total)	22.95	22.70	24.09

*Average of 11 composite samples.

+Average of 15 composite samples.

#Average of 8 composite samples.

Manure from 44 cows was stored at the site from December 1974 until October 1975 and from December 1975 until October 1976. The site was monitored weekly only when manure was being stored. Average manure characteristics for 1975 and 1976 are presented in Table 2.

ANALYSIS OF RUNOFF AND MANURE

Manure and runoff were analyzed by the following procedures: solids by drying at 105°C; total-N by the semimicro Kjeldahl procedure (1); NH_4-N and NO_3+NO_2-N by steam distillation (2); total-P by the cholorstannous-molybdate method after nitric-perchloric digestion; total-K, Mg, and Ca in nitric-perchloric extracts by atomic absorption; and chemical oxygen demand (COD) by the method used for analysis of wastewater (8).

SURVEY OF VERMONT DAIRY FARMERS

A five-page questionnaire was developed to learn what farmers might do both in the absence and presence of external regulation.

A commercial dairy herd was defined as one having 20 or more milking cows. Under this definition there were 3,346 herds in Vermont in 1975, which formed the population base of the study. Questionnaires were mailed to a 50 percent random sample of dairymen and 874 usable surveys, or nearly 55 percent, were returned. Proportionally the returned surveys reflected the same percentage of "small", "medium", and "large" size herds that appear in the population.

TABLE 2. AVERAGE MANURE CHARACTERISTICS AT NORTH HERO SITE

Characteristic % (dry wt. basis)	1975	1976
NH_4-N	0.73	0.89
Total-N	2.15	2.24
P	0.46	0.51
K	1.64	1.16
Dry wt. (% of total)	23.49	19.45

SECTION 5

RESULTS AND DISCUSSION

PERFORMANCE OF LOW-COST STORAGE FACILITY AT UVM SPEAR STREET FARM

During the first cleanout, care had to be taken not to spin the tractor wheels because spongy pockets remained in the limestone base. After one season of wetting and drying, the base hardened to what might be described as a soft plaster of paris. Traction was sufficient for bucking and loading manure. The tire tread did not dig into the stone unless special efforts were made to spin the tires. Sharp turns were made without ridging the limestone. Skid-steer loaders worked as well as tractor loaders. In general, traction was as good or better than what could be achieved on concrete.

Very little stone was mixed into the manure from the action of tractor tires. Stone could be dislodged with the teeth of the loader, but normal bucking procedures with a level bucket picked up a few stones. About 2 cm of manure was left on the surface of the limestone as the site was emptied.

No evidence was found that the plastic underliner was punctured, although at points it was covered with as little as 5 cm of limestone. No evidence of puncture was observed where stone was cleared away by hand.

Of the three sizes of limestone used, the 2 cm peastone would be recommended, although all held up well. The stone passing a 3 3/4 cm screen was somewhat porous, and the rock fines evidenced more sponginess than did the 2 cm peastone.

Acidic conditions of manure may dissolve limestone. For this reason and the fact that a small amount of limestone may be removed with the manure, additional limestone may need to be spread over the surface from time to time, although after 2 years of use it was not yet necessary.

These limestone bases will not work well where water is continuously ponded on the surface, and there is poor subsurface drainage. Bonding between particles is decreased as pore spaces are filled with water. Interlocking surfaces easily slip because of the lubricating effect of water. Partial support is given to vehicles for a single pass, but continued back-and-forth motion destroys the structural strength of the base.

Retaining walls of cedar post and treated plank were adequate for low manure stacks of approximately 2 m. Higher stacks would require substantially stronger walls to retain the manure. Untreated plank could have been used and would probably last as long as the untreated cedar posts.

RUNOFF FROM UVM SITES

Runoff Volume

In 1975 the major runoff events occurred during winter and early spring (Table 3). While only 25 percent of the precipitation fell during January through April, 69 percent of the annual runoff from the site occurred during these months. The small amount of water retained by the frozen and wet manure during the winter months probably induced the relatively high amount of runoff from the site. In addition, an accumulation of snow at the site from the adjacent field was observed. The runoff during the early months of 1975, as well as during February and March 1976, was greater than the precipitation that fell on the site. For the remainder of both years, runoff was less than the amount of precipitation, reaching as low as 22 percent of precipitation during September 1975 and 14 percent of precipitation in December 1976. Evaporation from the manure pile between most rainfalls probably provided considerable water storage capacity. Part of this stored moisture was then evaporated. However, the unusually cold weather during December 1975 caused little of the 5 cm of precipitation (all occurring as snow) to run off the site during that month. Total runoff for 1975 was 589 l/m^2 surface area or on a cow basis averaged 12.2 l/cow/day. Increasing stack height, thereby reducing the ground surface area needed for manure storage, would lessen the total runoff from the system but probably not greatly change the runoff expressed on a surface area basis. However, less bedding in the manure would probably reduce the storage capacity for water and result in increased runoff from the system.

Runoff Quality and Nutrient Loss

During individual storm or thaw-induced runoff events, the concentrations of elements in the runoff decreased during peak flows and then increased as the flow returned to base levels (Figure 3). The greatly increased flow during these events offsets the decrease in concentrations, causing increased

TABLE 3. PRECIPITATION AND RUNOFF VOLUME FROM UVM SITE 1.

Month	Total precipitation (cm)	Runoff (kl)	% of precipitation recovered in runoff*
<u>1975</u>			
January	4.34 (0.30)+	44.2	217
February	4.78 (2.39)	39.6	177
March	7.62 (1.93)	51.1	144
April	3.20 (2.46)	54.1	361
May	2.84	9.7	73
June	7.14	12.1	36
July	8.13	11.5	30
August	7.92	8.9	24
September	8.51	8.9	22
October	10.01	17.4	37
November	7.42 (0.99)	8.1	23
December	5.08 (5.08)	9.9	42
<u>1976</u>			
January	6.60 (3.66)	24.2	78
February	3.43 (0.84)	44.7	278
March	3.46 (1.42)	50.4	311
April	5.97 (trace)	14.4	52
May	18.36	62.7	73
June	10.74	13.9	28
July	8.03	7.0	19
August	10.49	38.1	78
September	8.61	32.7	81
October	11.28	9.2	17
November	3.25 (2.75)	5.6	38
December	4.06 (4.06)	2.8	14

+ Water equivalent of snow in parentheses.

* 1 cm precipitation at site equivalent to 4,680 liters.

AMOUNT IN RUNOFF

	(KG/2 HOURS)												TOTAL (KG)
TOTAL-N	.103	.104	.112	.148	.168	.236	.171	.158	.147	.127	.112	.112	1.698
P	.006	.006	.005	.010	.013	.014	.010	.009	.008	.007	.006	.006	.100
K	.098	.098	.097	.134	.159	.201	.157	.144	.131	.112	.099	.099	1.529
SOLIDS	1.37	1.33	1.25	1.25	1.72	2.16	2.04	1.98	1.86	1.59	1.40	1.40	19.35

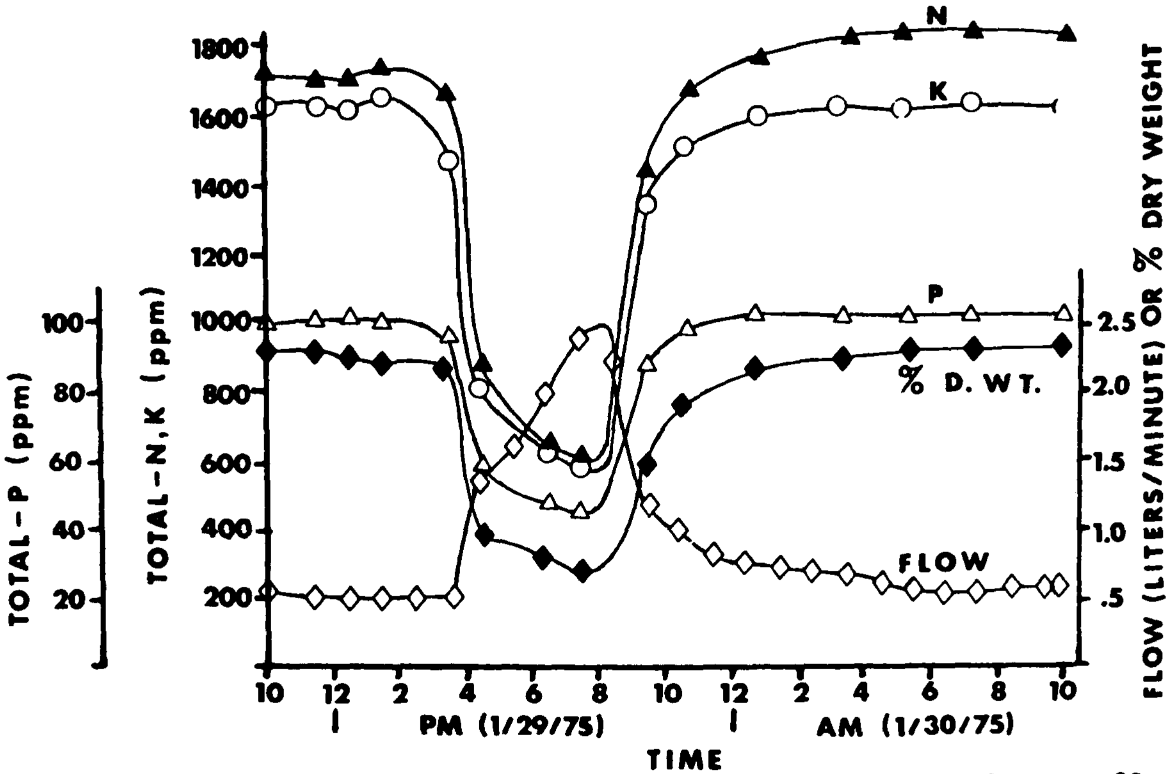

Figure 3. Runoff characteristics and nutrient loss during January 29, 1975 rainstorm (0.75 cm precipitation).

nutrient and solid loss. Monthly nutrient loss was, therefore, related to runoff volume (shown for nitrogen in Figure 4).

The ranges in runoff concentrations of solids, Cl, and COD, and nutrients were substantial (Table 4). The maximum values were near those reported for runoff from unpaved beef cattle feedlots and seepage from dairy manure stacks (4, 9). Very low concentrations coincided with runoff events during early January when little manure was stored at the site. The runoff had definite potential to pollute small streams and ponds. Using the mean values for COD and flow rate and assuming no turbulence, runoff from the pile could deplete the dissolved O_2 in a stream with a flow rate of about 17 liters /sec (0.6 ft^3/sec)[1/]. In addition, the nitrogen and phosphorus contained in the runoff might stimulate the development of eutrophic conditions in a small stream or pond.

During 1975, nutrient losses in the runoff amounted to 6.02 kg N, 0.41 kg P, and 8.32 kg K/cow (Table 4). At current fertilizer prices (N, P, and K at 23, 43, and 12¢/lb respectively) the N, P, and K in the 1975 runoff/ cow is worth about $5.58. When other nutrients and the solids (82 kg/cow/yr) are taken into account, the potential economic value of the loss is even greater. The total amount of manure stored at UVM site 1 was calculated to be 12.3 metric tons wet weight/cow. Based on this estimate, the 1975 losses of solids, total-N, P, and K in the runoff as a percent of the amount stored in the facility were 2.9, 9.8, 2.9, and 19.7 percent respectively. Phosphorus appears to be closely associated with the solids while N and K are more mobile. About 73 percent of the nitrogen lost in runoff was as NH_4-N. The total losses of N during storage were probably enhanced by NH_3 volatilization during the warmer part of the year (See discussion of gaseous N losses below).

During 1976 the losses of solids, N, P, and K, were about 50 percent of those in 1975, even though water losses were slightly greater in 1976 (Table 4). The losses of solids, N, P, and K during 1976 were 44, 3.3, and 5.5 kg/ cow respectively. After July 1976, the manure at site 1 was covered with plastic sheeting as the facility was filled. The effluent entering the monitoring hut contained some runoff from the plastic in addition to seepage from

[1/] (15,543 mg COD/liter) x (8.96 x 10^{-3} liters/sec) = 139.3 mg COD/sec. If 139.3 mg COD were diluted in 17 liters of water, it would exert an O_2 demand equal to the solubility of oxygen in water (8 mg/liter).

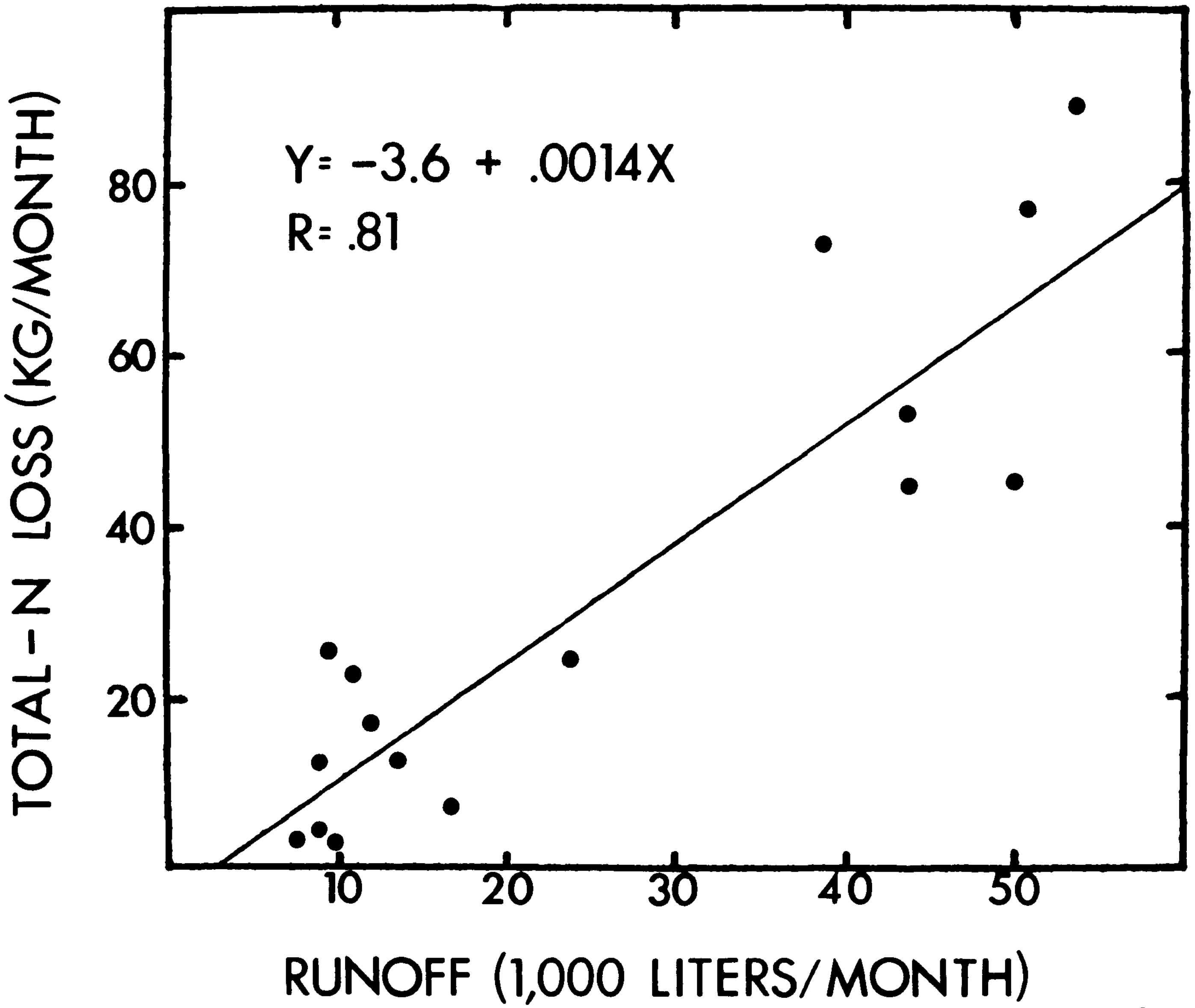

Figure 4. Relation of monthly total-N loss to monthly runoff volume from UVM site 1 (January 1975 through April 1976).

TABLE 4. RUNOFF CHARACTERISTICS AND LOSSES FROM UVM SITE 1 DURING 1975 and 1976*

	Runoff characteristics (ppm, wet basis)		Loss during	Loss during
	Range	Mean	1975 (kg/cow/yr)	1976 (kg/cow/yr)
Solids	1,400 - 57,200	18,000	82.02	44.29
Total-N	20 - 3,953	1,354	6.02	3.32
NH_4-N	6 - 2,795	991	4.41	2.32
P	7 - 255	92	0.41	0.29
K	83 - 5,400	1,870	8.32	5.47
Ca	tr - 1,330	384	1.71	0.97
Mg	6 - 590	128	0.57	0.48
Cl	64 - 3,842	1,335	5.94	3.39
COD	275 - 50,713	15,543	69.12	54.62
Flow rate (l/day)	0 - 6,975	775	4,447.27	4,932.27

*Manure was covered with plastic starting July 1976.

the manure. The runoff from the plastic could not be completely diverted around the monitoring intake.

SEEPAGE BENEATH THE BASE OF THE UVM FACILITY

One side of the facility was underlain with plastic protected by rock fines (site 1) while the other side was not (site 2). It is, therefore, possible to estimate the amount of water percolating through the base by comparing the amount of runoff from the two sides.

During January through June 1976, precipitation was 48.6 cm while runoff from sites 1 and 2 were 44.9 and 33.0 cm respectively. Thus about 24 percent of the precipitation that fell during the period apparently percolated through the base into the soil under site 2. While a very slowly permeable manure-gravel layer probably develops with time, after 1 year of use the base was apparently still quite permeable.

GASEOUS N LOSS FROM STORED MANURE AT UVM SITE

Gaseous N Loss from manure stacks may occur by two different mechanisms. As the surface dries NH_4^+ can be lost as NH_3. In addition, near the surface of a stack NH_4^+ might be nitrified into NO_2 and NO_3. Rainfall may subsequently leach these forms deeper in the stack where anaerobic conditions allow denitrification to occur. The distribution of N fractions in manure stacks suggests such a process (Table 5).

TABLE 5. NITROGEN FRACTIONS IN NORTH HERO MANURE STACK (July 28, 1976)

Horizontal depth into manure stack (cm)	Total-N	NH_4-N	NO_3+NO_2-N
	----------ppm (dry wt. basis)*----------		
Surface (0)	20,613	347	1,364
30	19,139	4,563	275
60	21,019	6,471	334

* Values are means of three different samples.

Concentrations of NH_4 in the runoff from site 1 during 1975 indicates that some N may have been lost by volatilization. During June through December of 1975, there is a decrease of NH_4-N as a percent of total-N (Figure 5), K, Na, Cl, and solids. Since the characteristics of the manure stored at the site during this period did not vary much from earlier manure, the reason for the decreased NH_4-N was probably gaseous N loss. Assuming this to be the case, NH_4-N loss by volatilization may be calculated by finding the amount of NH_4-N that would have been in the runoff if the 75.2 percent of the total-N occurring as NH_4 during January through May 1975 had also occurred June through December (instead of the 67 percent actually found). This calculation worked out to be about 0.18 kg N/cow. Adding this to the 1975 runoff losses would raise the estimate of annual N losses by only about 3 percent. Thus runoff appeared to be a much greater source of N loss than did loss in the gaseous state.

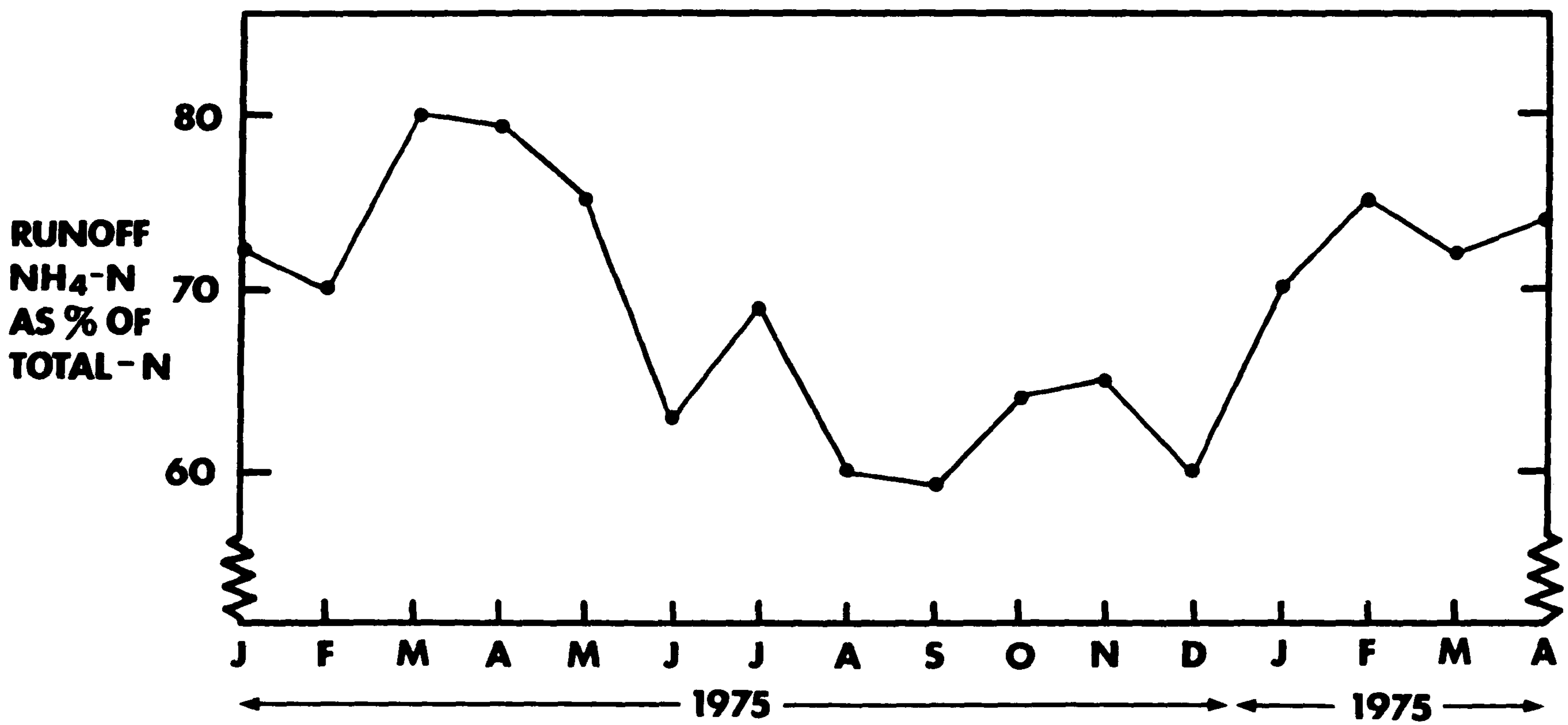

Figure 5. Runoff NH_4-N as a percent of total-N (January 1975 through April 1976)

RUNOFF FROM NORTH HERO SITE

During 1975 runoff losses/cow from the North Hero site (Table 6) were somewhat higher than losses from UVM site 1 (Table 4). At North Hero there was less runoff/cow but higher concentrations of solids and nutrients than at the UVM site. The relatively high stack at North Hero resulted in less ground surface occupied/cow than at UVM site 1 (10 and 15 m^2/cow respectively). Thus, less precipitation was intercepted/cow at North Hero. Runoff at North Hero during 1976 was greater than during 1975, probably due to the greater precipitation during 1976. The losses estimated as a percent of the amount stored were also higher in 1976 than in 1975 (Table 6). The exceptionally high percent K loss estimated for 1976 (40.8) may have been partly due to the very low K content in manure grab samples (Table 2). The grab samples may not have adequately represented the actual characteristics of the manure.

TABLE 6. RUNOFF LOSSES AT NORTH HERO SITE

	Loss during 1975 (kg/cow/yr)		Loss during 1976 (kg/cow/yr)	
Solids	50.1	(2.5)*	76.0	(3.6)
Total-N	4.9	(11.3)	6.8	(14.5)
NH_4-N	3.6	(26.7)	5.2	(28.0)
P	0.2	(1.7)	0.3	(2.6)
K	6.1	(18.1)	10.0	(40.8)
Ca	0.7		1.2	
Mg	0.4		0.7	
Liquid	2,230.5		3,887.6	

* Estimated loss as percent of amount stored at site (total wet weight of manure estimated at 433,500 and 574,388 for 1975 and 1976 respectively.)

DAIRY FARMER SURVEY

Tables 7 to 11 show the major statistical data reviewed from the questionnaires. Perhaps the major finding is that relatively few Vermont dairymen intend to adopt different manure handling practices because of what they perceive as prohibitive cost with few tangible benefits. Table 7 indicates that about 85 percent of the farmers feel that the total cost of alternative systems would be "very important" and this figure is significantly higher than any of the percentages appearing in the categories of specific benefits. It can be assumed that most commercial dairymen in Vermont would be unlikely to adopt new manure handling practices voluntarily.

Tables 8 through 11 show the summary of responses of dairymen to possible future environmental laws regarding manure handling. While there is some variation in response relative to herd size, the data suggests the following conclusions:

1. Most dairymen would adopt a wait-and-see attitude and could be expected to lobby against environmental regulations regarding new manure handling practices.
2. A relatively small percentage of dairymen would go out of business if regulations were passed. The statewide average of 29 percent of "definitely will" and "likely" can also be interpreted as an emotional overreaction at the time of the original mailing of the questionnaire.
3. If regulations were passed requiring that new manure systems be adopted, more than one-half of the dairymen would seek a government agency to cost-share construction.
4. Relatively few dairymen would comply and adopt new housing and milking technologies at the same time.

TABLE 7. SUMMARY OF RESPONSES OF ALL VERMONT COMMERCIAL DAIRYMEN TO POSSIBLE FUTURE ENVIRONMENTAL LAWS REGARDING MANURE HANDLING

	Definitely will	Likely	Unsure	Not likely	Definitely will not
	----------	P e r c e n t			----------
1. Will go out of dairy business	12	17	29	31	11
2. Will relocate business elsewhere-free of regulations	2	4	12	37	45
3. Will never comply even if it means getting fined for violations	5	8	31	31	25
4. Will get together with other dairy farmers to get regulations softened or repealed	24	35	24	11	6
5. Will change manure system even if there are no regulations passed	3	12	21	34	30
6. Will wait to see what other dairy farmers are doing before making my final decision	14	37	22	16	11
7. Will comply with regulations to get it over with	3	20	37	23	17
8. Will drop dairying and specialize in other agricultural products	4	11	24	35	26
9. Will comply and adopt new housing and milking technologies	2	6	25	34	33
10. Will comply with least costly system at the minimum level of the law	7	37	33	13	11
11. Will comply with a more effective system at higher cost because laws might get tougher in future	2	8	31	31	28
12. Will cut back herd size, take part-time job because the investment would be too much	4	10	21	32	33
13. Will try to increase herd size to justify increased capital expense of manure system	2	9	17	34	39

(continued)

TABLE 7. SUMMARY OF RESPONSES OF ALL VERMONT COMMERCIAL DAIRYMEN TO POSSIBLE FUTURE ENVIRONMENTAL LAWS REGARDING MANURE HANDLING

	Definitely will	Likely	Unsure	Not likely	Definitely will not
	Percent				
14. Will keep herd size same and absorb cost of new manure system	3	26	34	17	20
15. Will borrow money to have adequate manure handling system built	3	19	22	24	32
16. Will see if there is government agency that will cost-share with me	20	35	21	11	13
17. Will confer with county agent, SCS, Univ. Extension specialists, etc., for technical help on manure systems	27	38	17	8	10

TABLE 8. SUMMARY OF RESPONSES OF VERMONT DAIRYMEN WITH 20-39 COWS TO POSSIBLE FUTURE ENVIRONMENTAL LAWS REGARDING MANURE HANDLING

	Definitely will	Likely	Unsure	Not Likely	Definitely will not
	Percent				
1. Will go out of dairy business	18	24	31	18	9
2. Will relocate business elsewhere free of regulations	2	3	13	36	46
3. Will never comply even if it means getting fined for violations	3	9	41	23	24
4. Will get together with other dairy farmers to get regulations softened or repealed	22	35	24	8	11
5. Will change manure system even if there are no regulations passed	3	5	22	32	38
6. Will wait to see what other dairy farmers are doing before making my final decision	15	36	27	10	12
7. Will comply with regulations to get it over with	3	11	41	26	19
8. Will drop dairying and specialize in other agricultural products	6	13	32	27	22
9. Will comply and adopt new housing and milking technologies	3	4	25	28	40
10. Will comply with least cost system at the minimum level of the law	8	32	31	13	16
11. Will comply with a more effective system at higher cost because laws might get tougher in future	2	5	26	29	38
12. Will cut back herd size, take part-time job because the investment would be too much	7	16	25	22	30

(continued)

TABLE 8. SUMMARY OF RESPONSES OF VERMONT DAIRYMEN WITH 20-39 COWS TO POSSIBLE FUTURE ENVIRONMENTAL LAWS REGARDING MANURE HANDLING

	Definitely will	Likely	Unsure	Not likely	Definitely will not
	---------- P e r c e n t ----------				
13. Will try to increase herd size to justify increased capital expense of manure system	1	5	20	24	50
14. Will keep herd size same and absorb cost of new manure system	4	17	39	15	25
15. Will borrow money to have adequate manure handling system built	3	9	21	28	39
16. Will see if there is government agency which will cost-share with me	12	28	26	17	17
17. Will confer with county agent, SCS, Univ. Extension specialists, etc., for technical help on manure systems	16	36	23	11	14

TABLE 9. SUMMARY OF RESPONSES OF VERMONT DAIRYMEN WITH 40-79 COWS TO POSSIBLE FUTURE ENVIRONMENTAL LAWS REGARDING MANURE HANDLING

	Definitely will	Likely	Unsure	Not Likely	Definitely will not
	------------ Percent ------------				
1. Will go out of dairy business	10	15	30	36	9
2. Will relocate business elsewhere free of regulations	3	4	13	35	45
3. Will never comply even if it means getting fined for violations	6	7	27	36	24
4. Will get together with other dairy farmers to get regulations softened or repealed	25	35	23	12	5
5. Will change manure system even if there are no regulations passed	3	11	20	37	29
6. Will wait to see what other dairy farmers are doing before making my final decision	15	37	20	17	11
7. Will comply with regulations to get it over with	4	23	34	21	18
8. Will drop dairying and specialize in other agricultural products	2	11	23	36	28
9. Will comply and adopt new housing and milking technologies	2	7	23	36	32
10. Will comply with least cost system at the minimum level of the law	6	39	32	14	9
11. Will comply with a more effective system at higher cost because laws might get tougher in future	2	9	30	33	26
12. Will cut back herd size, take part-time job because the investment would be too much	3	9	20	34	34

(continued)

TABLE 9. SUMMARY OF RESPONSES OF VERMONT DAIRYMEN WITH 40-79 COWS TO POSSIBLE FUTURE ENVIRONMENTAL LAWS REGARDING MANURE HANDLING

	Definitely will	Likely	Unsure	Not Likely	Definitely will not
	-----------------	P e r	c e n	t	----------
13. Will try to increase herd size to justify increased capital expense of manure system	2	9	16	37	36
14. Will keep herd size same and absorb cost of new system	2	29	32	19	18
15. Will borrow money to have adequate manure handling system built	4	20	23	23	30
16. Will see if there is government agency that will cost share with me.	22	37	20	8	13
17. Will confer with county agent, SCS, Univ. Ext. specialists, etc., for technical help on manure systems	28	40	14	9	9

TABLE 10. SUMMARY OF RESPONSES OF VERMONT DAIRYMEN WITH 80 OR MORE COWS TO POSSIBLE FUTURE ENVIRONMENTAL LAWS REGARDING MANURE HANDLING

	Definitely will	Likely	Unsure	Not Likely	Definitely will not
	Percent				
1. Will go out of dairy business	7	11	27	37	18
2. Will relocate business elsewhere free of regulations	1	4	7	43	45
3. Will never comply even if it means getting fined for violations	3	9	30	29	29
4. Will get together with other dairy farmers to get regulations softened or repealed	24	34	27	11	4
5. Will change manure system even if there are no regulations passed	6	23	20	30	21
6. Will wait to see what other dairy farmers are doing before making my final decision	12	41	17	18	12
7. Will comply with regulations to get it over with	1	26	40	20	13
8. Will drop dairying and specialize in other agricultural products	2	8	18	45	27
9. Will comply and adopt new housing and milking technologies	2	7	26	38	27
10. Will comply with least costly system at the minimum level of the law	7	35	35	15	8
11. Will comply with a more effective system at higher cost because laws might get tougher in future	1	12	39	27	21
12. Will cut back herd size, take part-time job because the investment would be too much	2	5	16	40	37

(continued)

TABLE 10. SUMMARY OF RESPONSES OF VERMONT DAIRYMEN WITH 80 OR MORE COWS TO POSSIBLE FUTURE ENVIRONMENTAL LAWS REGARDING MANURE HANDLING

	Definitely will	Likely	Unsure	Not likely	Definitely will not
	---------- P e r c e n t ----------				
13. Will try to increase herd size to justify increased capital expense of manure system	2	10	18	39	31
14. Will keep herd size same and absorb cost of new manure system	4	31	35	14	16
15. Will borrow money to have adequate manure handling system built	2	32	21	19	26
16. Will see if there is government agency which will cost-share with me	30	40	14	7	9
17. Will confer with county agent, SCS, Univ. Extension specialists, etc., for technical help on manure systems	39	38	13	3	7

TABLE 11. DEGREE OF IMPORTANCE OF ECONOMIC AND ENVIRONMENTAL FACTORS OF ALTERNATIVE MANURE HANDLING SYSTEMS FOR FARMS OF VARIOUS HERD SIZES

	very important	some importance	not important	Total
	Percent			
Save chore labor:				
20-39 cows	49	26	25	100
40-79 cows	55	27	18	100
80 or more cows	66	21	13	100
State average	56	25	19	100
Save fertilizer values:				
20-39	65	23	12	100
40-79	75	18	7	100
80 or more cows	80	19	1	100
State average	73	20	7	100
Avoid odor complaints:				
20-39 cows	15	32	53	100
40-79 cows	18	27	55	100
80 or more cows	24	34	42	100
State average	18	30	52	100
Avoid water pollution:				
20-39 cows	36	35	29	100
40-79 cows	36	36	28	100
80 or more cows	45	32	23	100
State average	38	35	27	100
Total cost of system:				
20-39 cows	83	12	5	100
40-79 cows	88	10	2	100
80 or more cows	84	15	1	100
State average	86	11	3	100

REFERENCES

1. Bremner, J.M. Total nitrogen. 1965a. In C.A. Black, et al. ed. Methods of Soil Analysis, Part 2. Agronomy 9: 1171-1178. Amer. Soc. of Agron., Madison, Wisconsin.

2. Bremner, J.M. 1965b. Inorganic forms of nitrogen. In C.A. Black, ed. Methods of Soil Analysis, Part 2. Agronomy 9: 1179-1237. Amer. Soc. of Agron., Madison, Wisconsin.

3. Converse, J.C., C.O. Cramer, G.H. Tenpas, and D.A. Schlough. 1975. Properties of solid and liquids from stacked manure. In Managing Livestock Wastes, Proceedings of the 3rd International Symposium on Livestock Wastes.

4. Gilbertson, C.B., T.M. McCalla, J.R. Ellis, O.E. Cross, and W.R. Woods. 1970. The Effect of Animal Density and Surface Slope on Characteristics of Runoff, Solid Wastes and Nitrate Movement on Unpaved Feed Yards. Nebraska Agr. Exp. Sta. Bull. No. 508, Lincoln, Nebraska.

5. Hensler, R.F., R.J. Olden, O.J. Attoe, W.H. Paulson, and R.F. Johannes. 1970. Effect of method of manure handling on crop yields, nutrient recovery and runoff losses. Transactions of the Amer. Soc. Agr. Eng. 13: 726-731.

6. Klausner, S.D., P.J. Zwerman, and D.F. Ellis. 1976. Nitrogen and phosphorus losses from winter disposal of manure. J. Environ. Qual. 5: 46-49.

7. Midgley, A.R., and D.E. Dunklee. 1945. Fertility Losses from Manure Spread During the Winter. Vt. Agr. Exp. Sta. Bull. No. 523, Burlington, Vermont.

8. Orland, H.P., ed. 1965. Standard Methods for The Examination of Water and Waste Water. Amer. Public Health Assoc. Inc., New York, N.Y.

9. Tenpas, G.H., D.A. Schlough, C.O. Cramer, and J.C. Converse. 1972. Roofed vs. unroofed solid manure storages for dairy cattle. ASAE Paper No. 72-949. Amer. Soc. Agr. Eng., St. Joseph, Michigan.

10. Young, R.A., and C.K. Mutchler. 1976. Pollution potential of manure spread on frozen ground. J. Environ. Qual. 5:174-179.

APPENDIX
RUNOFF EVENTS MONITORED AT UVM SITES

THAW EVENT 3/4/76 3/5/76

UVM Site #1	Time Interval	Time Interval (hrs)	Effluent (liters)	Solids	Inorg. N	Total N	Mg	Ca	K	Na	P	Cl
				Loss/hour kg								
	1	1	126	1.37	.08	.10	.01	.02	.14		.01	.09
	2	1	162	1.73	.09	.12	.01	.02	.17		.01	.12
	3	1	162	1.30	.08	.11	.01	.02	.16		.01	.11
	4	1	162	1.30	.10	.12	.01	.02	.19		.01	.10
	5	1	150	1.26	.08	.11	.01	.02	.16		.01	.10
	6	1	150	1.26	.09	.11	.01	.02	.16		.01	.10
	7	1	144	1.24	.08	.11	.01	.02	.16		.01	.10
	8	1	135	1.20	.08	.11	.01	.02	.15		.01	.09
	9	1	132	1.17	.08	.11	.01	.02	.15		.01	.10
	10	1	129	1.16	.08	.11	.01	.02	.17		.01	.10
	11	1	126	1.16	.08	.11	.01	.02	.17		.01	.10
	12	1	126	1.17	.08	.11	.01	.02	.17	NOT RUN	.01	.10
	13	1	135	1.30	.10	.12	.01	.03	.17		.01	.11
	14	1	174	1.72	.13	.16	.02	.03	.20		.01	.14
	15	1	237	1.78	.14	.19	.02	.03	.25		.01	.19
	16	1	300	1.98	.18	.21	.02	.03	.26		.02	.23
	17	1	300	1.98	.18	.20	.02	.05	.28		.02	.23
	18	1	297	1.93	.15	.18	.02	.04	.27		.02	.16
	19	1	297	2.14	.16	.19	.02	.03	.27		.02	.18
	20	1	300	2.19	.17	.21	.02	.04	.29		.02	.18
	21	1	360	3.35	.22	.25	.03	.05	.35		.02	.21
	22	1	480	4.46	.29	.33	.04	.06	.45		.03	.30
	23	1	510	4.40	.29	.32	.04	.05	.49		.03	.32
	24	1	540	4.40	.28	.32	.04	.05	.49		.03	.32
	25	1	540	4.40	.29	.32	.04	.05	.49		.02	.31

(continued)

(continued)

THAW EVENT 3/4/76 3/5/76

UVM Site #1	Time Interval	Time Interval (hrs)	Effluent (liters)	Loss/hour Solids	Inorg. N	Total N	Mg	Ca	K	Na	P	Cl
				kg								
	26	1	720	4.61	.39	.43	.05	.03	.63	NOT RUN	.05	.40
	27	1	780	4.29	.41	.45	.05	.03	.64		.05	.42
	28	1	828	4.97	.42	.46	.05	.06	.61		.05	.42
	29	1	720	3.96	.37	.41	.05	.04	.51		.05	.38
	30	1	630	3.84	.34	.39	.04	.04	.47		.05	.32
	31	1	510	3.57	.31	.35	.04	.04	.48		.04	.30
	32	1	450	2.61	.29	.30	.04	.04	.42		.03	.28
	33	1	444	3.46	.30	.34	.04	.04	.46		.03	.30
	34	1	360	3.31	.25	.39	.03	.05	.36		.03	.31
	35	1	300	1.94	.17	.21	.02	.02	.26		.02	.24
	36	1	270	1.82	.18	.21	.02	.03	.25		.02	.23
	37	1	238	2.33	.20	.23	.02	.03	.29		.02	.19
	38	1	221	2.36	.17	.20	.02	.03	.23		.02	.18
	39	1	204	1.73	.15	.18	.02	.02	.21		.02	.16
	40	1	202	1.94	.16	.18	.02	.03	.25		.01	.16
	41	1	180	1.80	.14	.17	.02	.03	.19		.01	.15
	42	1	180	1.78	.14	.17	.02	.03	.24		.01	.15
	43	1	162	1.52	.12	.15	.02	.02	.16		.01	.13
	44	1	162	1.55	.12	.15	.02	.02	.19		.01	.14
	45	1	162	1.76	.14	.16	.02	.03	.19		.01	.14
	46	1	162	1.62	.12	.16	.02	.02	.20		.01	.14
	47	1	162	1.62	.14	.16	.02	.02	.19		.01	.14
	48	1	162	1.53	.14	.16	.02	.02	.18		.01	.14
Total loss throughout storm period -		-	14383	111.27	8.75	10.24	1.13	1.50	13.82		195	9.51

RAINSTORM - 9/2/76

Total of .25 cm rain during 10 minute period (1:00-1:10 p.m.)

UVM Site #1	Time Interval	Time Interval (hrs)	Effluent (liters)	Solids	Inorg. N	Total N	Mg	Ca	K	Na	P	Cl
		Loss/0.17 hours										
				kg								
	1	.17	1.5	.04	.001	.002	.0003	.0002	.01	.001	.0001	.005
	2	.17	42.5	.39	.010	.020	.0040	.0100	.05	.009	.0010	.030
	3	.17	30.0	.60	.010	.020	.0040	.0040	.09	.010	.0020	.060
	4	.17	8.5	.19	.004	.007	.0010	.0009	.03	.005	.0005	.020
	5	.17	5.0	.12	.003	.004	.0006	.0005	.02	.003	.0003	.010
	6	.17	4.0	.09	.002	.003	.0005	.0004	.01	.002	.0002	.009
	7	.17	4.0	.09	.002	.003	.0005	.0003	.01	.002	.0002	.009
Total loss throughout storm period	-	-	95.5	1.52	.032	.059	.0109	.0163	.22	.032	.0043	.143

RAINSTORM 10/8/76 - 10/9/76
(5.99 cm Rain)

UVM Site #1	Time Interval	Time Interval (hrs)	Effluent (liters)	Loss/hour: Solids	Inorg. N	Total N	Mg	Ca	K	Na	P	Cl
				kg								
	1	1	87	.40	.01	.02	.005	.010	.07	.010	.003	.04
	2	1	96	.60	.02	.03	.008	.010	.01	.020	.005	.06
	3	1	87	.26	.01	.01	.003	.005	.04	.004	.004	.02
	4	1	72	.42	.01	.02	.007	.020	.07	.010	.003	.04
	5	1	65	.39	.01	.02	.006	.010	.06	.010	.003	.04
	6	1	55	.34	.01	.02	.005	.010	.06	.010	.002	.04
	7	1	47	.36	.01	.02	.005	.009	.05	.009	.002	.03
	8	1	40	.36	.01	.02	.004	.009	.05	.010	.002	.03
	9	1	36	.35	.01	.02	.004	.009	.05	.010	.002	.03
	10	1	29	.28	.01	.02	.004	.007	.04	.008	.002	.03
	11	1	25	.24	.01	.02	.003	.006	.04	.007	.002	.02
	12	1	22	.21	.01	.01	.002	.005	.04	.007	.001	.02
	13	1	22	.24	.01	.01	.002	.005	.04	.007	.001	.02
	14	1	25	.25	.01	.02	.003	.006	.04	.007	.001	.03
	15	1	36	.36	.02	.02	.004	.009	.06	.010	.002	.04
	16	1	40	.39	.02	.03	.005	.010	.07	.020	.002	.04
	17	1	40	.39	.02	.03	.003	.005	.06	.010	.001	.04
	18	1	36	.39	.01	.02	.004	.010	.06	.010	.002	.03
	19	1	42	.44	.01	.03	.005	.010	.07	.010	.002	.04
	20	1	180	1.73	.06	.10	.02	.050	.26	.040	.009	.15
	21	1	72	.65	.02	.03	.006	.02	.10	.020	.003	.05
	22	1	72	.60	.02	.03	.010	.02	.08	.010	.003	.04
	23	1	72	.61	.02	.03	.010	.02	.08	.010	.003	.05
	24	1	72	.32	.01	.02	.005	.009	.06	.010	.002	.03
Total loss throughout storm	-	-	1370	10.58	.36	.60	.13	.28	1.65	.279	.062	.96

RAINSTORM 4/22/77 - 4/25/77
(5.84 cm Rain)

			Loss/hour									
UVM Site #1	Time Interval	Time Interval (hrs)	Effluent (liters)	Solids	Inorg. N	Total N	Mg	Ca	K	Na	P	Cl
				kg								
	1	8	4.8	.04	.002	.004	.0005	.001	.006	.0010	.0002	.004
	2	2.25	21	.18	.009	.010	.0020	.004	.020	.0040	.0009	.010
	3	5	20	.11	.001	.010	.0010	.004	.020	.0040	.0008	.010
	4	13	23	.10	.005	.009	.0020	.004	.020	.0030	.0020	.009
	5	6.25	43	.17	.010	.020	.0030	.008	.008	.0060	.0020	.020
	6	5	78	.44	.030	.040	.0080	.020	.070	.0200	.0080	.050
	7	16.25	95	.54	.040	.050	.0090	.020	.080	.0200	.0100	.050
	8	4.5	105	.50	.040	.050	.0100	.020	.080	.0200	.0200	.050
	9	6	86	.43	.030	.040	.0070	.020	.060	.0100	.0080	.040
	10	5	2.2	.01	.001	.001	.0001	.001	.002	.0004	.0001	.001
Total loss throughout storm period	-	-	3686.7	19.49	1.334	1.829	.3321	.779	2.883	.6905	.3871	1.879

RAINSTORM 4/22/77 - 4/25/77
(5.84 cm Rain)

			Loss/hour									
UVM Site #2	Time Interval	Time Interval (hrs)	Effluent (liters)	Solids	Inorg. N	Total N	Mg	Ca	K	Na	P	Cl
				kg								
	1	8	1.6	.02	.001	.001	.0002	.0002	.004	.001	.0001	.002
	2	2.25	6	.07	.003	.004	.0009	.0010	.010	.003	.0002	.009
	3	5	8	.09	.004	.006	.0010	.0020	.020	.004	.0004	.012
	4	13	35	.34	.020	.030	.0040	.0080	.070	.010	.0003	.050
	5	6.25	64	.61	.003	.005	.0020	.0060	.020	.005	.0020	.008
	6	5	99	.44	.020	.030	.0060	.0200	.090	.020	.0040	.050
	7	16.25	75	.44	.020	.030	.0070	.0200	.080	.020	.0040	.050
	8	4.5	102	.60	.040	.050	.0100	.0200	.110	.030	.0040	.070
	9	6	85	.54	.030	.040	.0080	.0200	.090	.020	.0070	.060
	10	5	3	.02	.001	.020	.0004	.0008	.004	.001	.0002	.002
Total loss throughout storm period	-	-	3619.1	24.39	1.103	1.671	.3119	.7943	3.595	.881	.1657	2.544

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/2-78-078	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Alternate Methods of Manure Handling		5. REPORT DATE April 1978 issuing date
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Frederick R. Magdoff, Grant D. Wells, Arthur E. Smith, Steven Goldberg, and John Amadon		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Agricultural Experiment Station, University of Vermont, Burlington, Vermont 05401		10. PROGRAM ELEMENT NO. 1BB770
		11. CONTRACT/GRANT NO. R-803883
12. SPONSORING AGENCY NAME AND ADDRESS Robert S. Kerr Environmental Research Laboratory-Ada,OK, Office of Research and Development, U.S. Environmental Protection Agency - Ada, OK, Ada, Oklahoma 74820		13. TYPE OF REPORT AND PERIOD COVERED Final (7/1/75 - 6/30/77)
		14. SPONSORING AGENCY CODE EPA/600/15

15. SUPPLEMENTARY NOTES

Part of the material in this report will be published in Transactions Amer. Soc. Agri. Engin.

16. ABSTRACT

The objectives of this research project were to (a) construct an inexpensive storage facility for solid dairy cow manure, (b) evaluate its performance and the extent of pollutants in runoff from storage facilities, and (c) determine current manure handling practices in Vermont and dairy farmers' attitudes and expectations with regard to possible future regulations on manure handling.

A storage facility was constructed at the University of Vermont (UVM), Animal Sciences Research Center (Spear Street Farm) and runoff from the site was channeled through sampling huts. A second site was established on a dairy farm in North Hero, Vermont. Runoff from the stacked manure was sampled weekly.

The quality and quantity of runoff from the storage sites indicate a substantial potential to pollute. Runoff from open stacks of manure should, therefore, be contained in a lagoon and irrigated on cropland. Alternately, runoff could be eliminated by covering the manure.

A survey of Vermont commercial dairy farmers (20 or more milking cows) indicated that most felt they could not afford the cost of changing manure handling systems. Only three percent of all dairymen definitely intended to change manure handling systems. However, most felt that saving the fertilizer value of manure would be a more important reason for them to change systems than would be reduced chore time.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Waste disposal, Agricultural wastes, Water pollution, Runoff, Fertilizers	Dairy manure, Storage, Handling	43F 68D

18. DISTRIBUTION STATEMENT RELEASE TO PUBLIC	19. SECURITY CLASS (This Report) UNCLASSIFIED	21. NO. OF PAGES 47
	20. SECURITY CLASS (This page) UNCLASSIFIED	22. PRICE

EPA Form 2220-1 (9-73)

☆ U. S. GOVERNMENT PRINTING OFFICE: 1978-757-140/6830 Region No. 5-11