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Distribution Costs for Dry Fertilizer Cooperatives

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PREFACE

Preparation of this report was financed by cooperative research agreement 43-3J31-2011 between the Agricultural Cooperative Service (now Rural Business and Cooperative Development Services, Rural Development Administration), USDA, and the North Dakota State University Agricultural Experiment Station. John Dunn, CS/RDA/USDA, served as liaison; and David Cobia, director of Burdick Center for Cooperatives, was the principal investigator. This report also contributed to NDSU Ag. Exp. Station Project 1383, "Marketing Strategies for Cooperatives."

Several individuals from CENEX-LO'L, equipment dealers, construction companies, and other industry contacts provided data for synthetic models. The assistance of Richard Schott was especially helpful. Merv Carlson, Bill Hunt, Jerry Schmidt, and Bill Stevens, all CENEX-LO'L field staff, provided useful feedback. Susan Wehri performed the delivery simulations.

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Key words: cooperatives, fertilizer distribution, delivery costs

ABSTRACT

Economic-engineering cost data and a simulation model was used to analyze the impact of sales area size and volume and equipment configuration on costs of custom application of bulk fertilizer by cooperatives. Fixed costs accounted for most of the custom application costs regardless of sales density or size of sales area for the relevant range of these variables in North Dakota. Increasing the radius of a sales area from 5 miles to 50 miles increased average costs by \$2.79/ton to \$32.26 per ton in Eastern North Dakota. Doubling sales by either doubling the size of the sales area or the sales density reduced average total costs by over a third for the smallest plant (500-ton storage) and over 40% for a 2,000-ton plant. Therefore, substantial savings, \$166,800/year in one scenario, can be realized by some sort of consolidation.

Although storage capacity placed little restriction on volume, more storage capacity than what is required for operations was recommended because of uncertainty in delivery during peak demand periods. Evaluating this type of risk was beyond the scope of this research.

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HIGHLIGHTS

This study was undertaken to evaluate the impact of sales area size, sales density, equipment configuration, and volume on costs for dry fertilizer distribution. An economic-engineering cost approach was used to analyze these relationships. Bench-mark statistics for operating conditions were taken from personal interviews conducted with the management of 13 selected dry fertilizer cooperatives representative of the range of dry fertilizer cooperatives across North Dakota and field representatives of regional fertilizer cooperatives to gather information on general operating characteristics of dry fertilizer facilities in the state.

Construction and operation costs for a range of sizes of facilities and custom application equipment pertinent to North Dakota were gathered from relevant fertilizer facility construction firms, equipment suppliers, and industry representatives. Six sizes of storage facilities were examined: 500, 800, 1,300, 2,000, 2,000 with tower, and 4,000 tons with tower storage facilities. Annual costs of operation for custom application were estimated by gathering costs for tender truck and applicator costs on a per mile basis. Then, tender miles, applicator miles, and acres applied/day were estimated using a computer simulation model.

Fixed costs of operation dominated total costs across the range of sales volumes examined for all sizes of facilities representative of eastern and western North Dakota. This indicated that the least-cost dry fertilizer facility for any sales volume was the smallest facility that could maintain liquidity of supplies within the season and that can operate at or near the capacity of its custom application equipment.

For firms representative of eastern North Dakota, annual fixed costs for delivery equipment became a larger percent of total costs as the size of the facility and equipment complements got larger. In fact, for facilities of 2,000 tons or more, fixed equipment costs were larger than fixed costs for facilities. This finding did not hold for firms representative of the western North Dakota where a lower percentage of fertilizer was custom applied. In this part of the state, fixed costs for equipment was generally less than 50% of fixed costs for facilities.

Variable distribution costs did not effect average total costs significantly for sales areas with a radius less than 50 miles. Increasing the size of the sales area from 5 to 50 miles in radius for any level of annual sales volume increased average total costs by \$2.79 to \$4.88/ton for firms representative of eastern North Dakota and by only \$0.89 to \$1.49/ton for firms representative of western North Dakota. Similarly, examination of a more limiting case where a firm expands its sales area while maintaining a constant sales density (market share) showed that the increased costs of custom application were more than offset by the reduced in average total costs obtained with the increased sales volumes. This finding held for the range of sales densities examined.

Therefore, the capacity of the delivery equipment was reached before cost inefficiencies of increasing the size of sales area could significantly impact average total costs in either region. The major impact of moving to a larger sales area for any sales density or sales volume was a reduction of acres that could be custom applied with a given equipment

complement. Thus, in the western regions of the state, smaller firms opted for lower cost, older technology equipment when they had few acres to custom apply. As the firms got larger and could operate custom application equipment near capacity, they could support newer and higher cost equipment.

Average total costs for custom application equipment complements increased for one new, 2, 3, 4, or 5 applicators increased by up to 118, 143, 194, 223, or 257% of the costs for a custom application complement with one used applicator. As the size of sales area or sales density increased, the effect on average total costs of increasing the size of equipment complement decreased.

Expansion of custom application in the western region of North Dakota is limited. A single applicator could cover a sales area of 50 miles in radius and a sales density of .5 tons/sq. mile in about 23 14-hour days. Sales areas with a radius smaller than 35 miles could be covered by a single applicator in less than 10 days. Since acres that are custom applied are so limited, a single firm with a large sales area could service most of the custom application needs within its area while competing firms provide only sales of product.

Consolidating the operation of 2 or more fertilizer cooperatives can yield substantial savings. Annual savings amounted to \$166,800 in one consolidation scenario for eastern North Dakota. Equivalent annual savings for a western North Dakota scenario was \$63,220.

Distribution Costs for Dry Fertilizer Cooperatives in North Dakota

Bruce L. Dahl, David W. Cobia, and Frank J. Dooley¹

INTRODUCTION

Many factors are affecting the fertilizer industry. Fertilizer usage in North Dakota, which increased steadily from 1950 to 1980, has leveled off. Regulation of the fertilizer supply industry is increasing which typically increases the cost of doing business. Environmental concerns have increased regulation of farmers' use of fertilizers. Alternative farm management strategies that reduce or eliminate commercial fertilizer use have arisen as a response to these concerns. Because of increasing regulation, farmers who previously applied fertilizers and pesticides may now consider custom application of these products rather than complying with regulations themselves. These changes have stimulated discussion regarding the impact of sales density, size of dry fertilizer storage facility, custom delivery application equipment, and size of sales area on distribution costs, especially for local cooperatives considering additional services, improvements, construction of new facilities, or consolidation.

Studies that examine the dry fertilizer industry are many and varied. Many of these studies have examined costs, pricing, and operating characteristics of retail fertilizer firms (Schulze and Akridge, Bullerdick and Akridge, Bullerdick et al., Hammond et al., Foster, et al. 1986). These studies have focused on assessing current costs and/or income for fertilizer firms based on type of firm (cooperative or investor oriented firms), type of product (dry, liquid, or anhydrous ammonia), level of profitability, and operation size (level of annual sales). Foster et al. (1986) examined aggregate levels of sales as they related to distance from the plant for the firms they surveyed.

Simpson (1990) examined the effects of increased investment for environmental containment on profitability of retail fertilizer firms. Costs of fertilizer application equipment have been examined (Willett, et al.; Simpson and Williams, 1985). However, previous research has not considered the effects of sales area size and density of sales on costs of individual dry fertilizer facilities and distribution equipment. This study was undertaken to examine the effects of these factors on costs for dry fertilizer facilities and distribution equipment. Alternatively, the appropriate size of sales area for existing facilities was estimated.

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BULK FERTILIZER TRADE IN NORTH DAKOTA

Use and Trade Flows

Fertilizer usage by farmers in North Dakota increased steadily from 1950 to 1980, but leveled off and declined up to 1990 (Figure 1). Fertilizer usage in North Dakota varies widely from region to region. Farmers in the dryer regions of western and south central North Dakota use little fertilizer, largely due to the uncertain response of crops to fertilizer. Also, less farmland is cropped, and more cropland is summer fallowed. In 1990, farmers in most of these western and south central counties of North Dakota purchased less than 5 tons of fertilizer/sq. mile, with many counties purchasing less than one ton/sq. mile² (Figure 2). Fertilizer use is more intense in the north central and eastern regions, where rain is more plentiful and less sporadic. Densities of fertilizer sales in these counties were generally 5 to more than 20 tons/sq. mile in 1990.

The three main forms of fertilizer (dry, liquid, and anhydrous ammonia) require different facilities and equipment. They are subject to different regulations and safety precautions. Most fertilizer usage in North Dakota is of the dry form. Densities of dry fertilizer sales in 1990 followed the same pattern as overall fertilizer sales, with lower densities in the western and south central counties to higher densities in the central and eastern counties. Densities ranged from less than one ton/sq. mile for many western and south central counties to a high of 12.5 tons/sq. mile in Grand Forks County (Figure 3). The density of fertilizer plant locations reflects these sales densities (Figure 4).

Most dry fertilizers supplied to cooperatives in North Dakota arrive by rail from Florida or by rail or truck from the Minneapolis-St. Paul area after barge shipment from Gulf ports (Schott). Therefore, shipping problems on the Mississippi River, rail car shortages, or lack of available trucks during peak demand times can affect the availability of dry fertilizers to local cooperatives.

Operating Characteristics of Selected Dry Fertilizer Cooperatives

Personal interviews were conducted with the management of 13 selected dry fertilizer cooperatives and field representatives of regional fertilizer cooperatives in North Dakota to gather information on the relevant range of operating characteristics of dry fertilizer facilities in the state. Criteria for selecting firms were location (east, west, and central portions of the state), facility size (small, moderate, and large), and firms with a reputation for maintaining relatively good records. Most firms handle combinations of dry, liquid, and/or anhydrous ammonia. However, in this study, only distribution costs of dry fertilizer were examined.

² Tons per square mile is used to measure sales density over other more common measures such as tons per acre because it more accurately relates to the distance required for delivery.

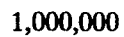


Figure 1. Total fertilizer use, North Dakota, 1950-1991.

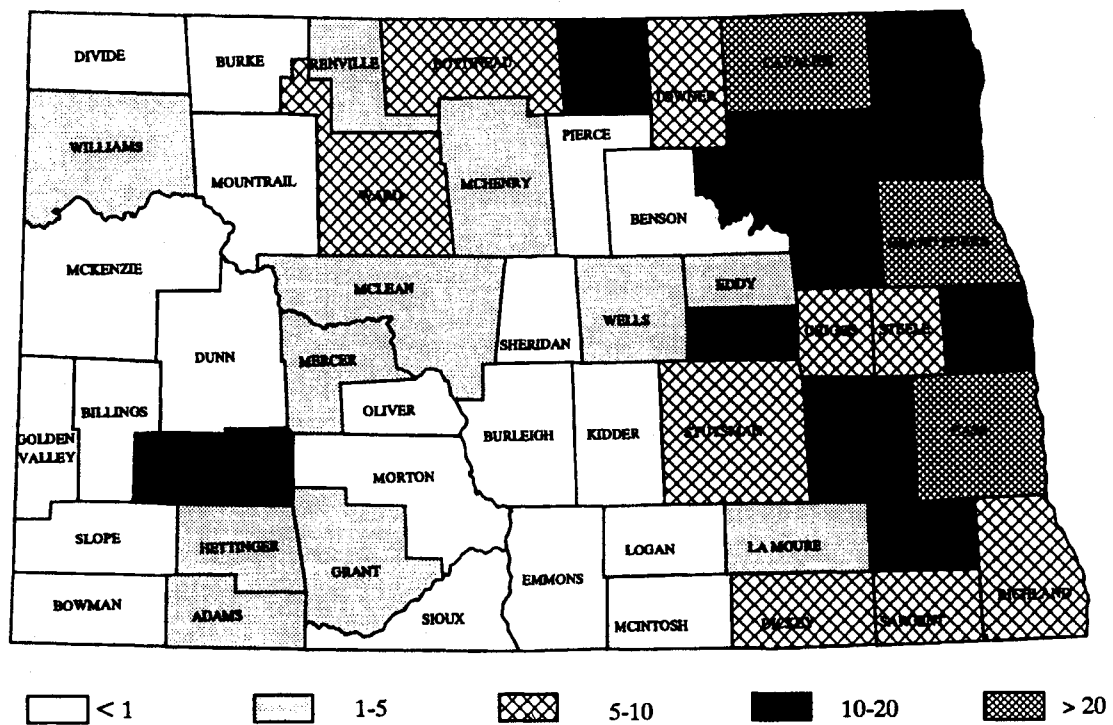


Figure 2. Density (tons/sq. mile) of total fertilizer use by county, North Dakota, 1990.

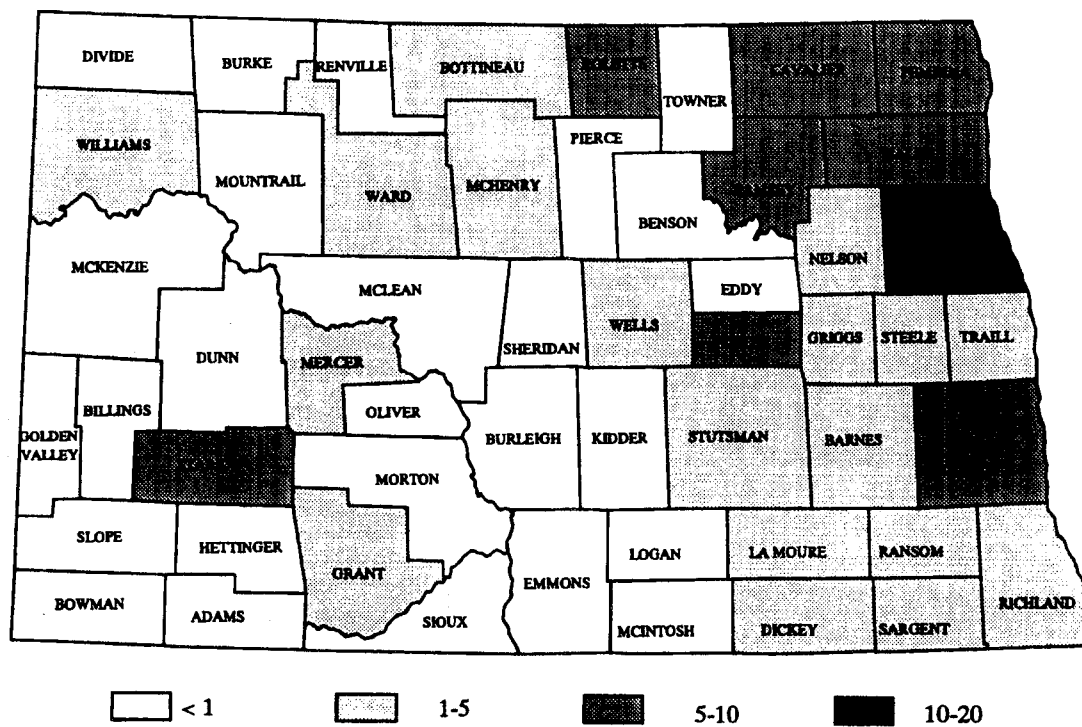


Figure 3. Density (tons/sq. mile) of dry fertilizer use by county, North Dakota, 1990.

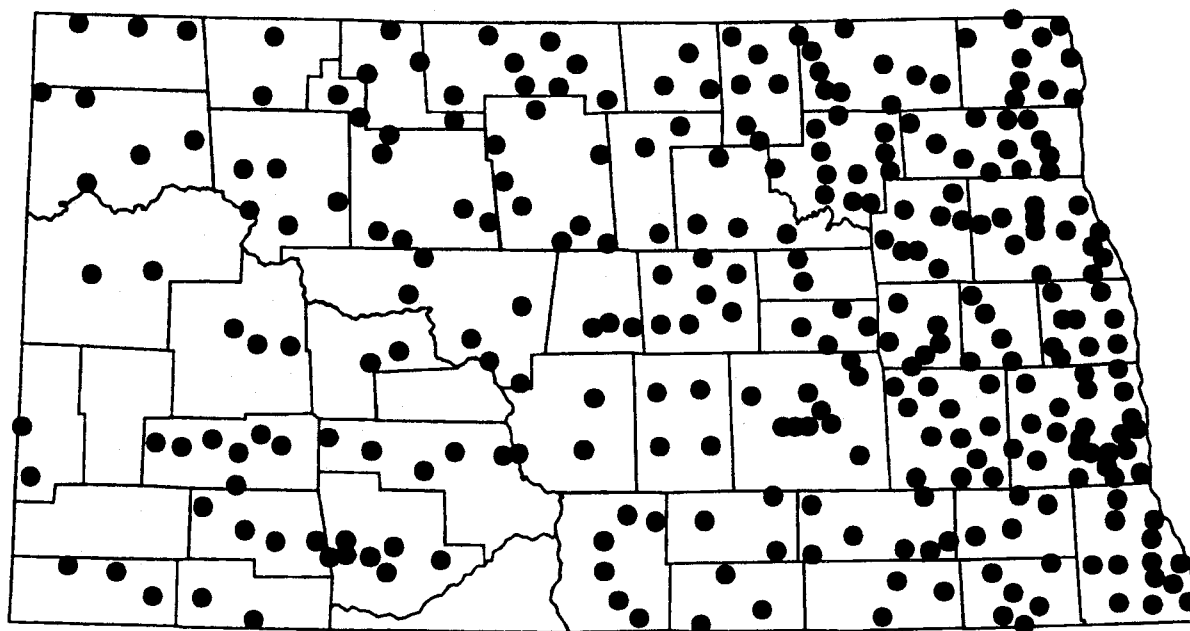
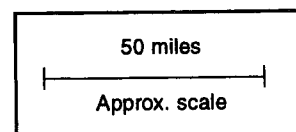


Figure 4. Locations of fertilizer plants, North Dakota, 1992.



General operating characteristics of cooperative dry fertilizer facilities varied widely across North Dakota. Firms in the southwest region typically did not focus on management of fertilizer sales and custom application as much as eastern firms did. Fertilizer trade in western North Dakota was more sporadic and highly dependent on weather. Managers of smaller plants in the southwest region of the state let farmers come to them and generally have older technology equipment if they provide custom application services (Hunt). As one moves northward and eastward, firms become more involved in providing services such as custom application and focus on employees with more experience and training, newer equipment, and reliable service. Inventory turnover ratios, application rates, and percent of total sales custom applied rise, especially for firms where production of potatoes and/or corn are prevalent. On the eastern side of the state, firms spend considerable management time and effort on scheduling deliveries to minimize miles driven by the applicator and maximize acres applied/ day for custom application.

The length of season and length of day were similar for all the firms surveyed. Most reported an average length of season of about 60 days lasting from early April to the end of May or first part of June. Some firms in the western region of North Dakota indicated they had applied fertilizer as early as February. Day length was generally 12 to 14 hours or sunrise to sunset. Since custom application of dry fertilizers occurs predominately in the springtime, this leaves a small window of opportunity in which custom application can occur. Therefore, firms custom applying dry fertilizers must have the equipment capacity to complete custom application during this limited time-frame. Furthermore, not all days during this period are suitable for custom application due to high winds, rain, or unfit field conditions. Most of the firms in the eastern and central regions indicated that bad weather conditions extended the length of the season. However, firms in the western region of the state indicated they had few days when they could not custom apply fertilizer.

The average size of facility and the equipment complement for a given size of facility increased from western to eastern North Dakota. In the southwest region of the state, custom applicators with airflows (newer technology) are owned by only the plants with the largest sales volumes. Smaller plants (700 to 800 tons of storage) with total annual sales up to 2,000 tons may have custom application using older technology such as a spinner box mounted on a truck frame. A few firms in the southwest region of the state had a plant storage capacity of 600 to 800 tons with no custom application and low sales volumes. Fertilizer trade in this area varied due to limited rainfall (Hunt).

Dry fertilizer facilities in the northwest region of North Dakota have an average of 1,200 tons in storage. Custom application was limited. Most fertilizer was farmer applied with grain drills. Rental trailers were popular. Custom application was done only by larger plants (1,500 tons of storage or more).

In the northeast region, plant size and percent of total sales that were custom applied increased from west to east. Plants smaller than 1,000 tons of storage generally did not have custom application. Firms with storage in the 1,200 to 1,300 ton range generally had one custom applicator, and plants with about 2,000 tons of storage generally had 2 applicators.

In the east central region, the typical plant size was 1,300 to 1,500 tons of storage. Most plants with less than 3,000 tons in annual sales did not have custom application. Of those that did, most had only one custom applicator.

Dry fertilizer facilities in the southeast region tended to have more custom application, smaller trade areas, and more competition from neighboring competitors. Plants smaller than 700 tons of storage did not custom apply fertilizer. Those with 700 to 1,000 tons of storage had one applicator and total sales of about 1,700 tons. Plants were typically 2,000 tons of storage with 2 to 3 applicators.

The percent of custom applied fertilizer sales increased from western to eastern North Dakota. Dry fertilizer facilities in the southwest generally custom apply only about 10% of their total dry fertilizer sales. Firms in the central portions of the state custom applied 30 to 50% of total annual sales. Some firms in the eastern region custom applied more than 60% of their total dry fertilizer sales. Of the firms surveyed, custom application ranged from 0 to 70% of total sales with an average of 35%.

The relative importance delivery to farms seemed specific to certain regions or firms. For example, farmers in some northern North Dakota areas purchased up to 60% of their total dry fertilizer to be delivered to their farm or truck by the local fertilizer cooperative. Other areas reported delivering from small amounts up to 30% with an average of 13% of total annual sales. The percent of fertilizer sales were direct transport loads delivered to the farm ranged from 0 to 17% of total annual sales with an average of 5%.

Inventory turnover ratios for the firms surveyed generally increased from less than one for firms in the western region of North Dakota to above 5 for some firms in the eastern region of the state. The 13 firms surveyed had an average turnover ratio of 2.47 and a range from .9 to 5.4. Sales densities for dry fertilizer cooperatives surveyed increased from .68 to 1.2 tons/sq. mile for firms in the western region to 3.8 - 5.2 tons/sq. mile for firms in the central region to 5.4 - 14.3 tons/sq. mile for firms in the eastern region. The radius of sales areas ranged from 10 to 44 miles with an average radius of 20.5 miles. There was a tendency among firms with larger storage facilities (2,000 tons) for the radius of sales area to increase from 20 miles in the eastern regions to 40 or more miles in western North Dakota. However, this trend was not as evident for firms with smaller storage facilities (≤ 1300 tons).

Custom applied dry fertilizer by cooperatives surveyed ranged from 0 to more than 50,000 acres/year. Each applicator averaged 13,080 acres. However, some firms reported up to 25,000 acres/applicator. Custom application rates (lbs./a) were higher in the east than in the west. They were highly crop specific, even within regions. Application rates were higher in corn and potato production areas or where crops were irrigated than in areas where wheat, summer fallow, and pasture were the primary uses of farmland. Average application rates for individual cooperatives increased from about 80 lbs./a for some co-ops in the west to over 300 lbs./a for co-ops in the east. Application rates for individual crops, particularly potatoes, were higher, from 400 lbs./a to over 800 lbs./a.

SPECIFICATION OF FACILITIES AND EQUIPMENT

An economic-engineering cost approach was used to analyze the impact of volume, sales density, sales area, and size of fertilizer facility on costs. This approach was used because average cost data from a survey of fertilizer distribution cooperatives were not reliable and not applicable to a given situation. Operating conditions for each co-op were unique. Accounting practices and depreciation schedules differed so from one another that direct comparisons were illogical. Furthermore, cropping patterns, agronomic practices, and custom applications rates varied across the state. For these reasons, standardized configurations of equipment and operating conditions and practices were synthesized to represent the continuum of sales volume, sales density, sales area, and operating practices across North Dakota. The survey of selected cooperative bulk fertilizer distributors provided bench-mark statistics for the synthesized models. Additional baseline information for these models was obtained from CENEX-LO'L business service and field representatives and equipment dealers.

Investment costs for construction of dry fertilizer facilities and acquisition of custom application equipment were gathered for a range of facility and equipment complement sizes relevant to North Dakota. Costs for facilities were established by identifying major components required for construction of various sizes of facilities and obtaining costs for these major components from firms familiar with dry fertilizer construction. Costs for equipment were obtained from firms selling custom application equipment. Relevant sizes of facilities and equipment were identified following consultation with local regional representatives for cooperatives, firms familiar with plant construction, and equipment retailers.

Storage and Mixing Facility

Four sizes of dry fertilizer storage facilities common to North Dakota were identified: 500, 800, 1,300, and 2,000 tons of storage (Schott). Firms with 2,000 tons of storage were specified with two common configurations: one constructed similar to smaller plants and one with a blending tower. Blending towers are becoming more popular for firms of about 2,000 tons of storage in North Dakota because of increased efficiencies for loading out the product. A sixth facility was specified larger than facilities common to North Dakota. Estimated costs of constructing storage facilities and fertilizer handling equipment required for the 6 sizes of dry fertilizer facilities were obtained from firms with experience in construction of dry fertilizer facilities.

All facilities were constructed with a chain conveyor to receive product from rail cars or trucks, a receiving leg, a screw conveyor to move product along the length of the building to different storage bins, a blender, and either a tower or load-out leg (Table 1). Construction of larger plants than 3,500 tons required sturdier construction materials and higher capacity equipment than plants smaller than 3,500 tons (Smith).

Table 1. Equipment capacity for selected sizes of dry fertilizer facilities, North Dakota, 1992.

Item (unit)	Facility size (tons of storage)					
	500	800	1,300	2,000	2,000 +tower	4,000 +tower
Storage facility (tons)	500	800	1,300	2,000	2,000	4,000
Stainless steel chain conveyor (tons/hr.)	60	60	90	90	90	200
Receiving leg (tons/hr.)	60	60	90	90	90	200
Screw conveyor (tons/hr.)	60	60	90	90	90	200
Blender (tons/min.)	4	4	4	4	4	4
Load-out/tower leg (tons/hr.)	120	120	120	120	120	120
Tower capacity (tons)	--	--	--	--	100	150
Attached office (sq. ft.)	400	500	600	700	700	800
Trackage (# of cars)	1	1	1	5	5	5

Sources: Hanson, Stuova Construction, Doyle Industries, and Smith.

Total construction costs for the 6 facilities ranged from a low of \$131,557 for the 500-ton facility to a high of \$561,161 for the 4,000-ton storage facility (Table 2). Costs/ton of storage decreased from \$263.11 to \$122.20 as plant size increased from 500 to 2,000 tons. However, adding of a tower blender to the 2,000-ton storage facility increased construction costs by \$95,000 or \$46/ton.

Distribution Equipment

Distribution equipment complements for the 6 dry fertilizer firms were specified to be typical for high density areas similar to southeastern or eastern North Dakota (Table 3) (Schott). These equipment complements were not typical of other areas in the state with lower sales densities (central and western North Dakota). Firms in these lower sales density areas typically had less equipment or it was of older technology. Furthermore, the 500-ton storage facility in the eastern region would not typically have a custom applicator, but was allocated one used applicator to allow examination of potential inefficiencies of custom application with smaller-than-normal facilities. Costs of delivery equipment were obtained

Table 2. Costs of major components for selected sizes of dry fertilizer facilities, North Dakota, 1992.

Item	Facility size (tons of storage)					
	500	800	1,300	2,000	2,000 +tower	4,000 +tower
Storage facility	37,500	56,000	84,500	120,000	120,000	258,765
Stainless steel chain conveyor	9,000	9,000	9,000	9,000	9,000	13,000
Receiving leg	8,000	8,000	8,000	8,000	8,000	23,000
Screw conveyor	9,000	9,000	10,600	12,000	12,000	27,000
Blender	28,000	28,000	28,000	28,000	--0--	--0--
Load-out leg	8,000	8,000	8,000	8,000	8,000	22,000
Tower & blender	--0--	--0--	--0--	--0--	120,000	150,000
Electrical work	5,000	5,000	5,000	5,000	8,000	13,000
Attached office	12,000	15,000	18,000	21,000	21,000	24,000
Trackage	15,057	15,057	15,057	30,396	30,396	30,396
Total cost	131,557	153,657	186,157	241,396	333,396	561,161
Cost/ton	263.11	192.07	143.20	120.70	166.70	140.29

Sources: Hanson, Stuova Construction, Doyle Industries, Smith and Lindemude.

from local equipment suppliers (Table 3). Custom applicators were specified as a new top-of-the-line terragator (includes chemical impregnation), a new standard model of terragator, a used terragator, and an older used truck to represent use in the western regions of North Dakota.

Tender trucks were specified as either gas or diesel trucks with 8-ton or 16-ton boxes. Fuel consumption was 5 mpg for trucks with gas engines and 7.5 mpg for trucks with diesel engines (Hall) (Table 4). The prices for gas and diesel used by bulk trucks were represented by average retail prices for fuel in 1992. The retail price of unleaded regular including state and federal taxes was \$1.135/gal. (U.S. Dept. of Energy). Prices reflecting costs for diesel were only available on a regional basis. The retail price of #2 distillates in pad 2 (North Dakota, Minnesota, Wisconsin, Nebraska, South Dakota, Iowa, Illinois), including North Dakota state and federal taxes was \$.991/gal. (U.S. Dept. of Energy). The cost of oil was assumed to be 15% of costs for gas and diesel (Hall). Costs for repairs and maintenance were \$.035/mile for both gas and diesel trucks (Hall). Costs for tires were assumed to be \$.0307/mile for 8-ton trucks and \$.0599 for 16-ton trucks based on new tire prices for each

Table 3. Distribution equipment for eastern region base scenario, North Dakota, 1992.

Item	Cost	Facility size (tons of storage)					
		500	800	1,300	2,000	2,000 +tower	4,000 +tower
	\$						
Custom applicators							
New (top of the line)	160,000	0	0	0	2	2	4
New	120,000	0	1	2	1	1	2
Used terragator	85,000	1	0	0	0	0	0
Used truck	40,000	0	0	0	0	0	0
Tender trucks							
16 ton (diesel)	55,251	0	0	2	3	3	4
8 ton	28,481	0	1	1	1	1	4
Rental cart spreaders	4,357	3	4	5	6	6	12
Articulated loader	26,000	0	0	0	1	1	2
Large skid steer loader	19,000	0	1	1	0	0	
Small skid steer loader	16,000	1	0	0	0	0	0
Pickups for soil testing	16,000	0	1	1	2	2	3
Soil Probe	2,950						
Land		1	2	3	5	5	7

Sources: Schott; Ag Chem, Inc.; Wallwork; Hall; Hanson; Hein; and Swanston Equipment, Inc.

truck and a useful tire life of 50,000 miles (Brad Ragan). Truck licenses for North Dakota were \$229 for the 8-ton truck and \$478 for the 16-ton truck (Cass County Motor Vehicle Department). An over-width license fee of \$50 was included for each applicator for the season. Insurance costs for licensed vehicles including tender trucks were \$335/truck (Geiszler).

Custom applicators were specified as diesel terragators or trucks. Fuel consumption was at the rate of 9 gal./hour (Ag Chem.). The cost of oil was 15% of the total costs for diesel (Ag Chem.). Repairs and maintenance were \$0.37/hour (Ag Chem.). Insurance for non-licensed equipment was \$.07/\$100 in value (Geiszler).

Table 4. Assumptions for dry fertilizer tender trucks, 1992.

Item	Tender truck capacity (tons)		
	8	16	16
Condition	new	new	new
Engine	gas	gas	diesel
Mpg	5	5	7
Cost chassis ¹ (\$)	23,396	31,992	37,992
Cost tender ² (\$)	5,085	5,949	5,949
Total truck cost (\$)	28,481	37,941	43,941
Fixed costs/year (\$)			
Depreciation	5,696	7,588	8,788
Insurance ⁴	335	335	335
License ⁵	229	478	478
Opportunity cost	<u>1,951</u>	<u>2,599</u>	<u>3,010</u>
Total	8,211	11,000	12,611
Variable costs/mile (\$)			
Fuel and oil	.2622	.2622	.1196
Maint. & repairs ¹	.0350	.0350	.0350
Tires ³	<u>.0307</u>	<u>.0599</u>	<u>.0599</u>
Total	.3279	.3571	.2145

¹ Hall.

² Hanson.

³ Brad Ragan Inc.

⁴ Geiszler.

⁵ Cass County Motor Vehicle Department.

COSTS OF OPERATION

Annual costs of operation for facilities and facility equipment were established based on estimates of labor and equipment requirements for the different sizes of dry fertilizer facilities from state industry representatives and equipment suppliers (Schott, Hanson, Smith). Operating costs for delivery and application of dry fertilizer were gathered from equipment suppliers on a per hour basis for applicators and per mile basis for tender trucks. Applicator hours and tender miles were estimated by simulating dry fertilizer deliveries and application with a computer simulation model. Annual costs of operation for facilities and equipment presented in this section are summarized in Table 5.

Table 5. Fixed and variable costs by size of fertilizer facility, North Dakota, 1992.

Item	Facility Size (tons)					
	500	800	1,300	2,000	2,000 +tower	4,000 +tower
<u>Plant & equipment</u>	(- - - - - \$/year - - - - -)					
Fixed						
Depreciation	6,578	7,683	9,308	12,070	16,670	28,058
Insurance: facility and inv.	1,917	2,992	3,993	5,591	5,591	11,964
directors & officers	750	750	1,500	1,500	1,500	2,500
Licenses	50	50	50	50	50	50
Lease - trackage	850	850	850	1,700	1,700	1,700
Labor						
Manager and assistant mgrs.	27,768	33,510	67,020	72,762	72,762	106,272
Bookkeeping staff	0	0	9,566	19,132	19,132	19,132
Opportunity cost: land and facilities	4,565	5,364	6,520	8,496	11,647	19,532
working capital	<u>170</u>	<u>207</u>	<u>451</u>	<u>547</u>	<u>547</u>	<u>770</u>
Total	42,648	51,406	99,258	121,848	129,599	189,978
Variable	(- - - - - \$/ton - - - - -)					
Advertizing and promotion	0.90	0.90	0.90	0.90	0.90	0.90
Utilities	0.04	0.04	0.04	0.04	0.04	0.02
Inspection and reporting fees	0.20	0.20	0.20	0.20	0.20	0.20
Maintenance and repair	5.09	5.09	5.09	5.09	5.09	5.09
Opportunity cost - working capital	<u>0.03</u>	<u>0.03</u>	<u>0.03</u>	<u>0.03</u>	<u>0.03</u>	<u>0.03</u>
Total	6.23	6.23	6.23	6.23	6.23	6.21
<u>Distribution equipment</u>	(- - - - - \$/year - - - - -)					
Fixed						
Depreciation	16,296	29,123	57,728	96,049	96,049	186,689
Maintenance and repair of						
rental equipment	1,045	1,394	1,742	2,091	2,091	4,182
Licenses - distribution equipment	50	346	1,352	1,947	1,947	3,329
Insurance	553	1,420	2,458	3,690	3,690	6,903
Opportunity cost:						
distribution equipment	3,907	6,982	13,840	23,028	23,028	44,759
working capital	<u>9</u>	<u>17</u>	<u>30</u>	<u>42</u>	<u>42</u>	<u>78</u>
Total	21,860	39,282	77,151	126,897	126,897	245,940

cont'd.

Table 5. (cont'd).

	Facility Size (tons)					
Item	500	800	1,300	2,000	2,000 +tower	4,000 +tower
	(- - - - - \$/ton - - - - -)					
<u>Distribution costs that vary with volume of sales</u> (loading & spreading)						
Insurance - application liability	2.4000	2.4000	2.4000	2.4000	2.4000	2.4000
Applicator						
Fuel and oil	10.2577	10.2577	10.2577	10.2577	10.2577	10.2577
Repairs	0.3700	0.3700	0.3700	0.3700	0.3700	0.3700
Wages: drivers	6.6204	6.6204	6.6204	6.6204	6.6204	6.6204
Tender trucks						
Fuel and oil	0.2612	0.2612	0.2612	0.2612	0.2612	0.2612
Repairs	0.0350	0.0350	0.0350	0.0350	0.0350	0.0350
Tires	0.0307	0.0307	0.0501	0.0526	0.0526	0.0453
Wages: drivers	5.6204	5.6204	5.6204	5.6204	5.6204	5.6204
Opportunity cost - working capital	<u>0.1390</u>	<u>0.1390</u>	<u>0.1390</u>	<u>0.1390</u>	<u>0.1390</u>	<u>0.1390</u>
Total	23.1647	23.1647	23.1647	23.1647	23.1647	23.1647
<u>Distribution costs that vary with density and size of sales area</u>						
Applicator	(- - - - - \$/hr - - - - -)					
Fuel and oil	10.2577	10.2577	10.2577	10.2577	10.2577	10.2577
Repairs and maint.	0.0237	0.0237	0.0219	0.0209	0.0209	0.0107
Wages: drivers	6.6204	6.6204	6.6204	6.6204	6.6204	6.6204
Tender trucks	(- - - - - \$/mile - - - - -)					
Fuel and oil	0.2612	0.2612	0.2612	0.2612	0.2612	0.2612
Repairs & maint.	0.0350	0.0350	0.0350	0.0350	0.0350	0.0350
Tires	0.0307	0.0307	0.0501	0.0526	0.0526	0.0453
Wages: drivers	0.1249	0.1249	0.1249	0.1249	0.1249	0.1249
Opportunity cost: working capital	<u>0.0942</u>	<u>0.0942</u>	<u>0.0942</u>	<u>0.0942</u>	<u>0.0942</u>	<u>0.0941</u>
Total	17.4171	17.4171	17.4153	17.4142	17.4142	17.4040

North Dakota facility with a 50-mile radius sales area.

Facilities

Depreciation

The straight line-method was used to calculate depreciation. Depreciation for the dry fertilizer facility was calculated based on the total cost of construction, assuming zero salvage value. Buildings were expensed over a 20-year period. Depreciation for trucks and fertilizer distribution equipment assumed a zero salvage value and was expensed over 5 years.

Insurance

Insurance costs were developed following normal coverage levels of local fertilizer co-ops. A local insurance representative supplied yearly insurance costs for each dry fertilizer facility. Costs were estimated assuming coverage of \$1 million in liability and average

inventory that would represent local cooperative insurance levels (Geiszler). The insurance premium for application liability was assumed to be \$8 per \$100 of application revenue. Application revenue was assumed to be \$3/a applied. Insurance for directors and officers was scaled from \$750 to \$2,500. If facilities became stressed or unprofitable, insurance levels could increase by as much as \$1,000 for any size of facility.

Licensing fees

An annual license fee of \$50 was required to distribute fertilizers within North Dakota. Furthermore, an inspection and tonnage report fee of \$.20/ton was required on all fertilizer sales (North Dakota Department of Health).

Lease for trackage

A range of costs for leasing of trackage and land was obtained from selected cooperatives across North Dakota. These costs ranged from \$460 to \$10,000. However, some of these leases included payments for land on which the facility was constructed. Costs were scaled from \$850 to \$1,700 to represent an average cost for leasing trackage next to the dry fertilizer facility. This range of costs was more in line with average payments made by the cooperatives surveyed after deleting observations containing payments for land under the facilities.

Management and labor

Labor requirements and wage rates for the dry fertilizer facilities were specified following indications of normal industry practices in eastern North Dakota (Schott). Industry representatives indicated that managers for small fertilizer plants had an average annual salary of \$18,000 to \$20,000. Managers for larger fertilizer facilities averaged \$30,000 to \$35,000. Therefore, salaries for managers were scaled from \$20,000 to \$40,000 for the 5 sizes of facilities. Custom applicator drivers were typically paid by the hour and hired for the season. Many of these employees were either full-time year-round employees of the fertilizer facility or were employees of another department of the co-op and moved to fertilizer application for the season. Tender truck drivers were hired by the hour for the fertilizer application season. Many firms hired older retired farmers to fill these positions. Average hourly wages for applicator and tender drivers were \$6.50 and \$5.50, respectively.

Workers compensation insurance for employees was specified as \$4.54 per \$100 of salary up to a maximum salary of \$12,000 (North Dakota Workers Compensation Bureau). Unemployment insurance for plant employees was \$2.80 per \$100 in salary up to maximum salary of \$12,200 (Job Service of North Dakota). Employees hired to do custom application carried a different designation than plant personnel and were not subject to unemployment insurance. Health insurance coverage for employees varied widely. However, most co-ops provided about \$400/month in health insurance premiums for permanent employees (Hucstra). Part-time employees were not covered.

Land

Most dry fertilizer facilities had land for the storage facility located near a railroad. This land may be in the center, on the edge, or outside of town. Since most sites were located near a railroad within local towns, land values for dry fertilizer facilities were more likely to reflect a higher valuation than agricultural land. Therefore, a proxy for the value of land for dry fertilizer facilities was assumed to be twice the value of farmland. A relationship was estimated between farmland values and the density of fertilizer sales to farmers by county across North Dakota using data from 1987.

$$FLV = (b_0 + b_1 * dfs) \quad (1)$$

where

FLV is farmland value in \$/a,

b₀ and b₁ are parameter estimates, and

dfs is density of fertilizer sales in tons/sq. mile.

This relationship allowed land costs in lower sales density areas (like western North Dakota) to reflect a lower land charge than in higher sales density areas. Land values for dry fertilizer facilities were calculated as twice the value of farmland using the following estimated equation for farmland values:

$$FLV = 254.411 + 30.763 * dfs \quad r^2 = .38 \quad (2)$$

(5.495)

Tables and figures (e.g., Appendix Table 1 and Figure 11) reporting fixed costs with changes in sales density incorporate this relationship. Therefore, contrary to normal convention, fixed costs reflected an increase, but this increase was limited to the positive relationship between sales density and land values on which the storage and mixing facility was located.

Opportunity costs

Opportunity costs represent foregone potential income by investing in land, equipment, and working capital rather than in its next best alternative. July 1993 short-term (6.53%) and long-term (6.85%) interest rates from the St. Paul Bank for Co-ops were used to calculate opportunity costs for working capital and investment in land, facilities, and equipment.

Opportunity costs were calculated for each class of expense: facilities and equipment, variable expenses for facilities, distribution expenses that vary with volume of sales, and distribution expenses that vary with the radius of the sales area. Working capital was assumed to be represented by one month of fixed and variable expenses. There was an upward bias in opportunity cost for plant and equipment because the initial purchase price, rather than average book value, was used in the calculation. This upward bias compensated for anticipated replacement costs.

Advertizing and Promotion

A charge of \$0.90/ton was included for advertising and promotion. This followed industry costs for advertising and promotion for facilities of similar size on a national level (Bullerdick and Akridge, 1991).

Utilities

The size of motors required for the equipment contained in the 5 facilities was gathered from equipment manufacturers (Hanson, Smith). Hoffman indicated a one-to-one relationship between motor horsepower and kilowatts used/hour would be appropriate for estimating kilowatts/hour for electric motors. This relationship was used to calculate utility cost of operation for the five facility sizes. Fertilizer sales/year were divided by fertilizer moved/hour for each of the equipment motors to arrive at total hours of motor use/year. Individual motor usage was multiplied by an average commercial cost for utilities (\$0.0648/Kwhr) in North Dakota to obtain a yearly cost for each individual motor (Energy Information Administration). Costs for each motor were added to arrive at a total utility cost/facility.

Maintenance and Repairs

The cost of repairs and maintenance for facilities was assumed to be \$5.09/ton of annual fertilizer sales. This follows industry costs for repairs and maintenance of facilities of similar size on a national level (Bullerdick and Akridge, 1991). Costs for repairs and maintenance of distribution equipment rented to farmers (trailer spreaders) were assumed to be 120% of list price divided over the useful life of the equipment (American Society of Agricultural Engineers, p. 299). Traditionally, rental equipment is repaired annually and therefore is classified as fixed rather than variable.

Break-even Milage for Gas and Diesel Tender Trucks

Break-even mileage between gas and diesel tender trucks of the same size was calculated because trucks with diesel engines have a higher initial investment cost, but lower operating costs than trucks with gas engines. The relationship between annual costs of operation and annual miles were estimated for gas and diesel engines (Table 4, Figure 5).

Break-even mileage between diesel and gas tender trucks was estimated using the following formula.

$$\text{Break-even milage} = \frac{fd - fg}{vg - vd} \quad (3)$$

where

fd is annual fixed cost of ownership for the diesel truck,
fg is the annual fixed cost of ownership for the gas truck,

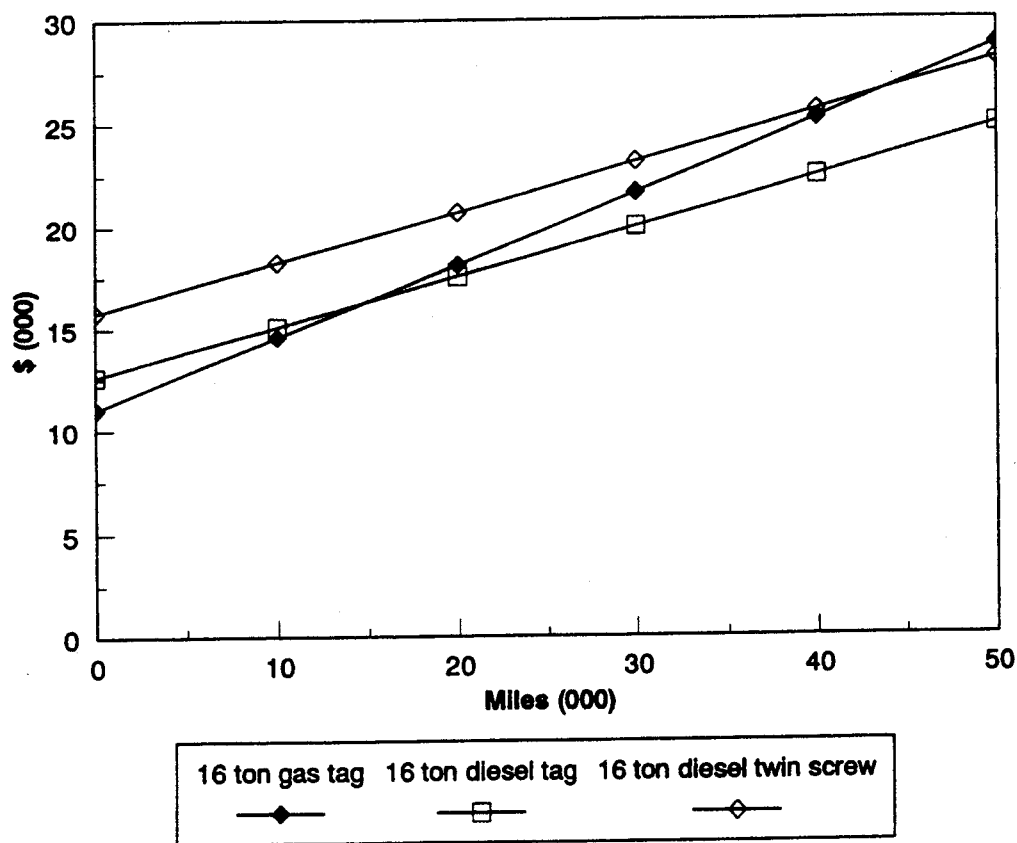


Figure 5. Annual truck cost for 16 ton tender fertilizer trucks, by type of truck and engine, 1992.

vd is the variable cost/mile for the diesel truck, and
vg is the variable cost/mile for the gas truck.

Using estimated costs/mile for both the gas and diesel trucks, truck owners should switch from a tag axle gas truck to a tag axle diesel truck when annual mileage exceeds 14,750 miles/year. Truck owners should switch from a gas tag axle truck to a diesel twin screw when annual mileage exceeds 43,755 when operating conditions for the truck are not limiting. Truck owners may want to consider the effect of increased maintenance and repair costs associated with operating under extreme conditions such as under heavy pulling and muddy conditions.

Simulation of Dry Fertilizer Distribution

Mileage, hours, and acres/day were estimated for dry fertilizer delivery equipment by simulating delivery and custom application of dry fertilizer for five sizes of sales areas (5-12.5- 20-35-and 50-mile radius). The width and length of the grid for each size of sales area were assumed to be equal to the diameter of the proposed sales area. Locations of fields to be custom applied within this grid were established using a random number generator where each location within the sales area had an equal chance of being selected. A set amount of fertilizer applied/a and field size was specified. Different scenarios were run for a range of selected application rates.

Deliveries were structured to consolidate them within an area and allow the tender truck and custom applicator to minimize miles driven. Mileage and total hours (driving + application + loading + unloading times) were estimated for fertilizer deliveries by tender trucks and custom applicators throughout the day based on load-out capacities, unloading capacities, average truck speed, average field application rate, and average custom applicator road speed (Table 6). Once hours had accumulated where another field could not be spread within a 14-hour period, the simulation was stopped; and acres applied, total hours, hours unloading, and miles driven for both the applicator and tender truck for the day were recorded. Simulations were run 10 times for each sales area, number of applicators, and application rate. Means of these 10 simulations were used to represent actual hours and mileage for each size of sales area, number of applicators, and application rates (Table 7).

Results from the simulation indicated that a single applicator applying 80 lbs./a could spread 840 acres/14-hour day with a 5-mile radius sales area (Table 7). Increasing the size of the sales area to a 50-mile radius reduced the acres applied to 444/14 hour day. As the size of the sales area was increased, the difference in acres applied/day among application rates also increased (Figure 6). However, the difference was largest between the 200 lbs./a and 400 lbs./a application rates. Differences between the lower application rates (200 lbs./a or less) were consistently less than 50 acres/day for the range of sales areas simulated. The large difference between 200 lbs./a and 400 lbs./a application rates was due to the heavier application rate requiring fills from both compartments of the tender truck/field rather than only one fill from a compartment/field required with the lower application rates. Thus, the fill time for the heavier rates of fertilizer application was higher both in the number of times the applicator had to stop to fill/field and the actual total loading time required, reducing the acres that could be spread/day.

Table 6. Assumptions for simulation of milage, acres applied/day, hours, and unloading hours for custom bulk fertilizer application, North Dakota, 1992.

Item	Units
Average applicator road speed	40 mph
Field application rate	85 acres/hr.
Applicator loading time	3500 lbs./min. + 5 min. for positioning
Truck loading time	15 min./load
Average truck speed	45 mph

Table 7. Simulated acres applied, applicator hours, miles, and tender truck miles by number of applicators, radius of sales area, and application rate for bulk fertilizer custom application, North Dakota, 1992.

Number of applicators	Radius	App. rate		Applicator		Tender miles
		(lbs./ac.)	Acres	Hours	Miles	
1	5	80	840	12.9	54.4	82.8
1	5	125	840	13.1	54.4	82.8
1	5	200	840	13.5	54.4	82.8
1	5	400	780	13.3	49.2	138.0
1	12.5	80	756	13.1	105.6	153.4
1	12.5	125	738	12.9	101.4	153.4
1	12.5	200	726	13.0	99.0	151.6
1	12.5	400	690	13.1	96.4	266.8
1	20	80	648	13.2	163.2	209.2
1	20	125	642	13.2	160.6	209.2
1	20	200	612	12.9	155.2	209.2
1	20	400	546	13.1	147.2	337.0
1	35	80	540	13.2	213.4	285.4
1	35	125	522	13.1	211.0	279.0
1	35	200	516	13.1	208.8	270.4
1	35	400	414	13.1	172.6	391.0
1	50	80	444	13.8	252.6	357.1
1	50	125	408	13.0	234.2	317.6
1	50	200	396	12.8	226.0	308.2
1	50	400	246	12.7	159.8	319.4
2	12.5	80	1626	27.1	197.0	319.2
2	12.5	125	1596	26.9	189.4	318.6
2	12.5	200	1548	26.6	182.0	318.6
2	12.5	400	1452	26.9	172.2	562.6
2	20	80	1416	27.1	263.2	485.9
2	20	125	1386	26.8	259.0	461.7
2	20	200	1368	26.8	255.0	440.4
2	20	400	1218	27.4	230.2	733.0
2	35	80	1158	26.9	361.2	605.1
2	35	125	1134	26.7	358.6	589.3
2	35	200	1116	26.7	356.2	580.1
2	35	400	900	26.7	287.2	830.0
3	12.5	80	2544	40.8	246.1	523.4
3	12.5	125	2496	40.5	239.5	501.6
3	12.5	200	2472	41.0	237.1	496.4
3	12.5	400	2274	40.7	211.7	909.8
3	20	80	2262	40.8	327.6	730.5
3	20	125	2238	40.8	323.4	710.3
3	20	200	2184	40.5	319.2	667.1
3	20	200	1956	40.7	300.6	1147.8
3	35	80	1734	39.6	456.0	899.7
3	35	125	1734	39.9	456.0	899.7
3	35	200	1734	40.2	451.4	895.8
3	35	400	1374	40.4	390.6	1309.4

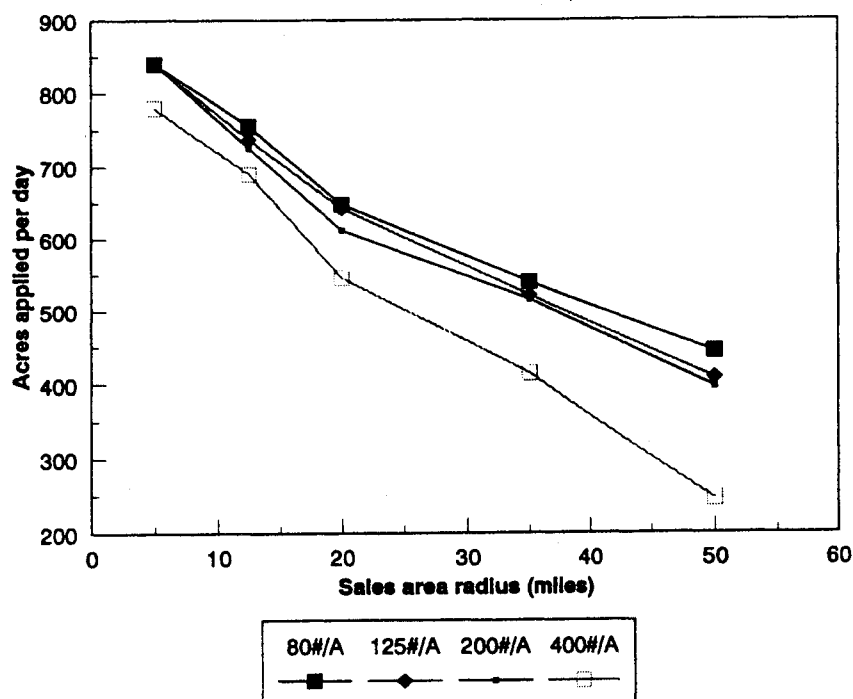


Figure 6. Simulated acres applied per day by one applicator by application rate (#/a) and sales area radius for bulk fertilizer application. (Source: Table 7)

The simulation assumed an average field size of 60 acres. If co-ops have consistently larger field sizes that can be custom applied with 1/2 of a tender truck load, then acres applied will be higher. However, if field sizes are smaller and tender trucks have limited compartments, acres/day will be reduced. One firm in the western region indicated that it had a low average field size and was looking to add tender trucks with 4 to 6 compartments to counter this problem. This would reduce the need to refill tender trucks repeatedly; however, it would also affect the calculation of tender mileage because the tender truck would have to follow the applicator from field to field between fills. Furthermore, the simplifying assumption that fields are randomly distributed within the sales area eliminates any interaction between sales density and tender or applicator miles. If more fields are located near the storage facility rather than at the perimeter of the sales area, applicator and tender miles would be reduced.

Using the results of the computer simulation, relationships were estimated for applicator miles/a, tender truck miles/a, and acres applied/day. Applicator highway miles were divided by acres spread to arrive at average applicator highway miles driven/a applied. A relationship estimated between the applicator highway miles/a applied and number of applicators, application rates, and radius of the sales area.

$$\text{appmiles} = b_0 + (b_1 * R) + (b_2 * DR2) + (b_3 * DR3) + (b_4 * r) + (b_5 * Rr) \quad (4)$$

where

appmiles is applicator highway miles/a applied,

b0-b5 are parameter estimates,

R is the radius of the sales area in miles,

DR2 is an interaction term between a binary variable for 2 applicators and the radius of the sales area,

DR3 is an interaction term between a binary variable for 3 applicators and the radius of the sales area,

r is the application rate in lbs./a, and

Rr is an interaction term between the radius of sales area and the application rate.

The resultant equation for estimating highway miles for up to 3 applicators is

$$\text{appmiles} = .011718 + .01076 * R - .0027 * DR2 - .0043 * DR3 - .00006 * r + .00005 * Rr \quad (5)$$

(44.544) (-17.517) (-27.713) (-2.360) (4.566)

$$R^2 = .9956.$$

Adding applicators within an area allows fertilizer co-ops to designate applicators to specific areas. Firms following this practice would reduce miles driven/applicator/a. Estimated applicator highway miles/a applied from the simulation declined by 80% with the addition of each applicator from one to 3 applicators. This relationship was used to estimate miles for more than 3 applicators. Therefore, estimating highway miles/a for 4, 5, and 6 applicators was 80%, 64%, and 51% of highway miles/a for 3 applicators, respectively.

Similarly, tender truck highway miles were divided by acres spread to arrive at average tender truck miles/a applied. A relationship was estimated between tender miles/a, application rates, and the radius of the sales area.

$$\text{Tendermiles} = c0 + (c1 * R) + (c2 * r) + (c3 * Hr) + (c4 * Rr) \quad (6)$$

where

Tendermiles is tender truck miles/a applied,

c0-c4 are parameter estimates,

R is the radius of the sales area in miles,

r is the application rate in lbs./a,

Hr is a binary variable for application rates over 200 lbs./a, and

Rr is an interaction term between the radius of the sales area and application rate.

This resulted in the following estimated relationship for tender truck mileage:

$$\text{Tendermiles} = .11613 + .01092 * R - .0008 * r + .30247 * Hr + .00003 * Rr \quad R^2 = .9901. \quad (7)$$

(17.530) (-6.626) (10.942) (11.868)

Tender truck mileage was not related to the number of applicators operated by the fertilizer co-op. Although applicators could be designated to areas to reduce miles driven between fields, tender truck mileage did not change with the addition of applicators because tender trucks were assumed to fill for two fields at one site and did not follow applicators between fields.

A relationship was estimated between acres applied/day, the number of applicators, the radius of the sales area, and the application rate.

$$\text{Acres/day} = c0 + c1 * \text{app} + c2 * \text{appR} + c3 * \text{appr} + c4 * R + c5 * Rr \quad (8)$$

where

Acres/day is acres custom applied/14-hour day,

c0-c5 are parameter estimates,
 app is the number of custom applicators,
 R is the radius of the sales area in miles,
 appR is an interaction term between the number of applicators and the radius of the sales area,
 appr is an interaction term between the number of applicators and the application rate in #/a, and
 Rr is an interaction term between the radius of the sales area and the application rate.

This relationship was used to determine the physical capacity of the application equipment.

The estimated relationship for acres/day was

$$\begin{aligned} \text{Acres/day} = & -172.26 + 1062.68 * \text{app} - 12.574 * \text{appR} - 0.2648 * \text{appr} + 4.27051 * R - .0066 * Rr \\ & (63.984) \quad (-21.533) \quad (-7.362) \quad (3.946) \quad (-2.458) \\ R^2 = & .9974. \end{aligned} \quad (9)$$

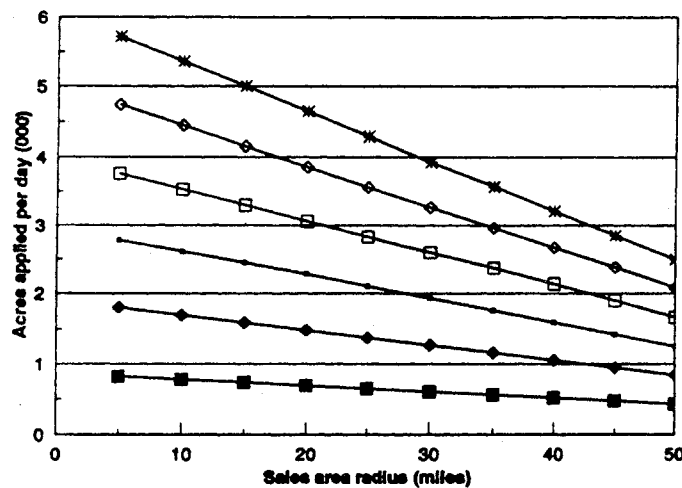
Using this relationship, a firm with 2 applicators, an average application rate of 80 lbs./a or 400 lbs./a, and a sales area 20 miles in radius could spread 1,483 or 1,271 acres/14-hour day, respectively, (Figure 7).

Days required to custom apply acres for each of the dry fertilizer firms surveyed were estimated using the above equation and survey responses. Acres applied/year were divided by acres applied/day to get an estimate of days required/season. Firms surveyed doing custom application required from 2.5 to 36.8 14-hour days to complete custom application (Figure 8).

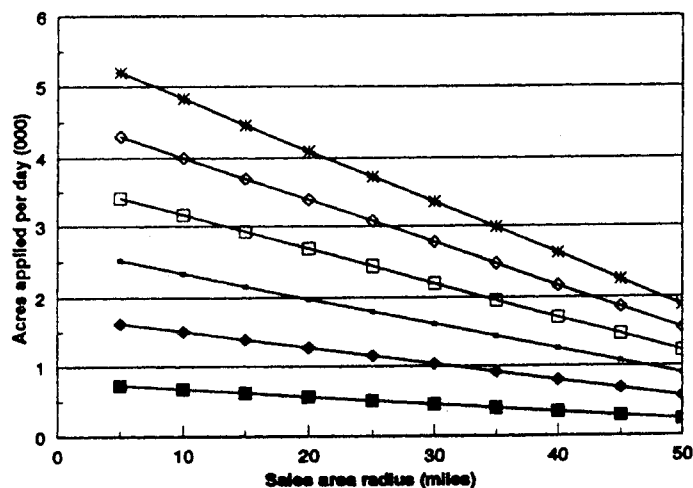
When days/season for the firms surveyed were compared by the radius of the sales area, three groups emerged. First was a group of firms that required less than 10 days to complete custom application. These firms were typically firms with no custom application or smaller facilities in western North Dakota. Second was a group of facilities that required 10 to 25 days to complete application. Third was a group that required more than 30 days to complete custom application. The gap between the required application days for groups 2 and 3 indicates that there are many facilities operating with excess custom application capacity. However, if the number of applicators was reduced by one for the firms with more than one applicator requiring 10 to 25 days to complete custom application, days required/season generally increased to about 30 days. Therefore, since applicators cannot be purchased in partial units, firms with excess custom application capacity were generally firms with one applicator and limited custom application and firms with more than one applicator that would be near the 30 day/season capacity of applicators, but had opted for purchase of an additional applicator.

Expanding Sales Areas

The potential to physically increase the size of sales areas for dry fertilizer cooperatives was examined for 6 levels of sales densities (.5, 1.5, 3, 5, 7, and 10 tons/sq.



Panel A 80 lbs./acre



Panel B 400 lbs./acre

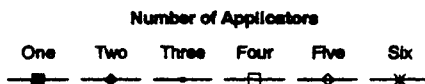


Figure 7. Simulated acres applied/day by number of applicators, radius of sales area, and specified application rates, North Dakota, 1992.

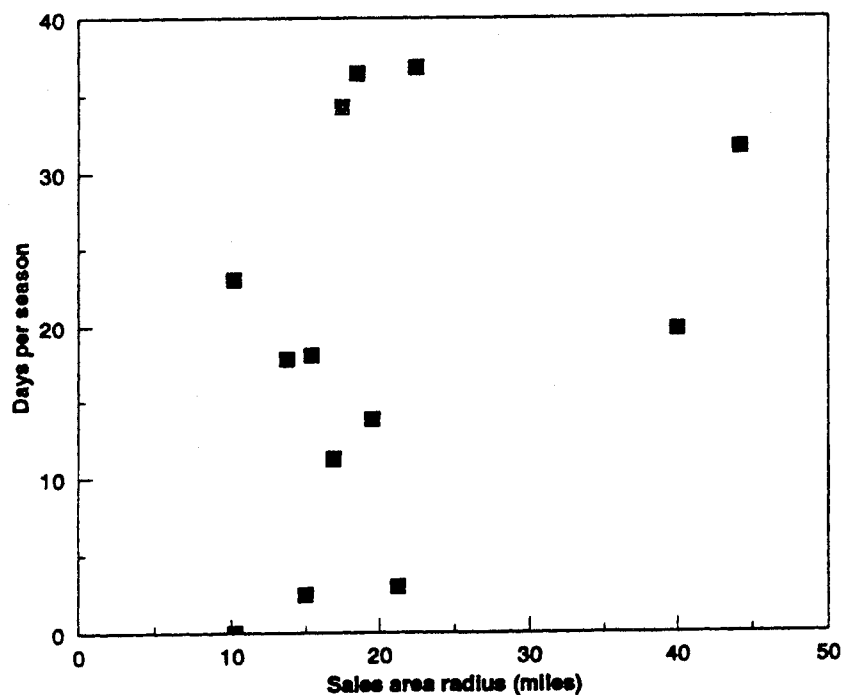


Figure 8. Estimated number of 14-hour days/season required to complete custom application for 13 selected dry fertilizer facilities, North Dakota, 1992.

mile). These sales densities were selected to represent the range of sales densities across North Dakota. Maximum levels of annual sales were estimated for a range of sales areas with these 6 levels of sales densities. Specified application rates (80, 125, 200, and 400 lbs./a) and percentage of fertilizer custom applied (10, 30, and 60%) were linked to these application rates to reflect operating characteristics associated with these application rates throughout North Dakota.

A single firm operating with a 30-mile radius sales area where the sales density of all firms was 3 tons/sq. mile (similar to many counties in central North Dakota) could obtain a maximum of 8,482 tons of sales (Figure 9, Panel A). A single firm in an area where the density of sales was .5 to 1.5 tons/sq. mile (similar to western North Dakota) could expect to obtain a maximum of 1,400 to 4,200 tons of dry fertilizer sales. If a single firm operated in an area where the density of sales was 7 to 10 tons/sq. mile (similar to many eastern North Dakota counties), the firm could obtain a maximum of 19,792 to 28,274 tons. This indicated that in areas where sales densities were small (1.5 tons/sq. mile or less), even single firms operating with sales areas less than 30 miles in radius would have a hard time achieving sales volumes to generate inventory turnover ratios larger than 1. However, a single firm operating in an area with high sales densities (7 to 10 tons/sq. mile) with a 10-mile radius sales area could obtain maximum sales of 2,200 to 3,100 tons. Increasing the size of the sales area for this firm to 15 miles in radius more than doubled the maximum sales to 4,950 to 7,070 tons.

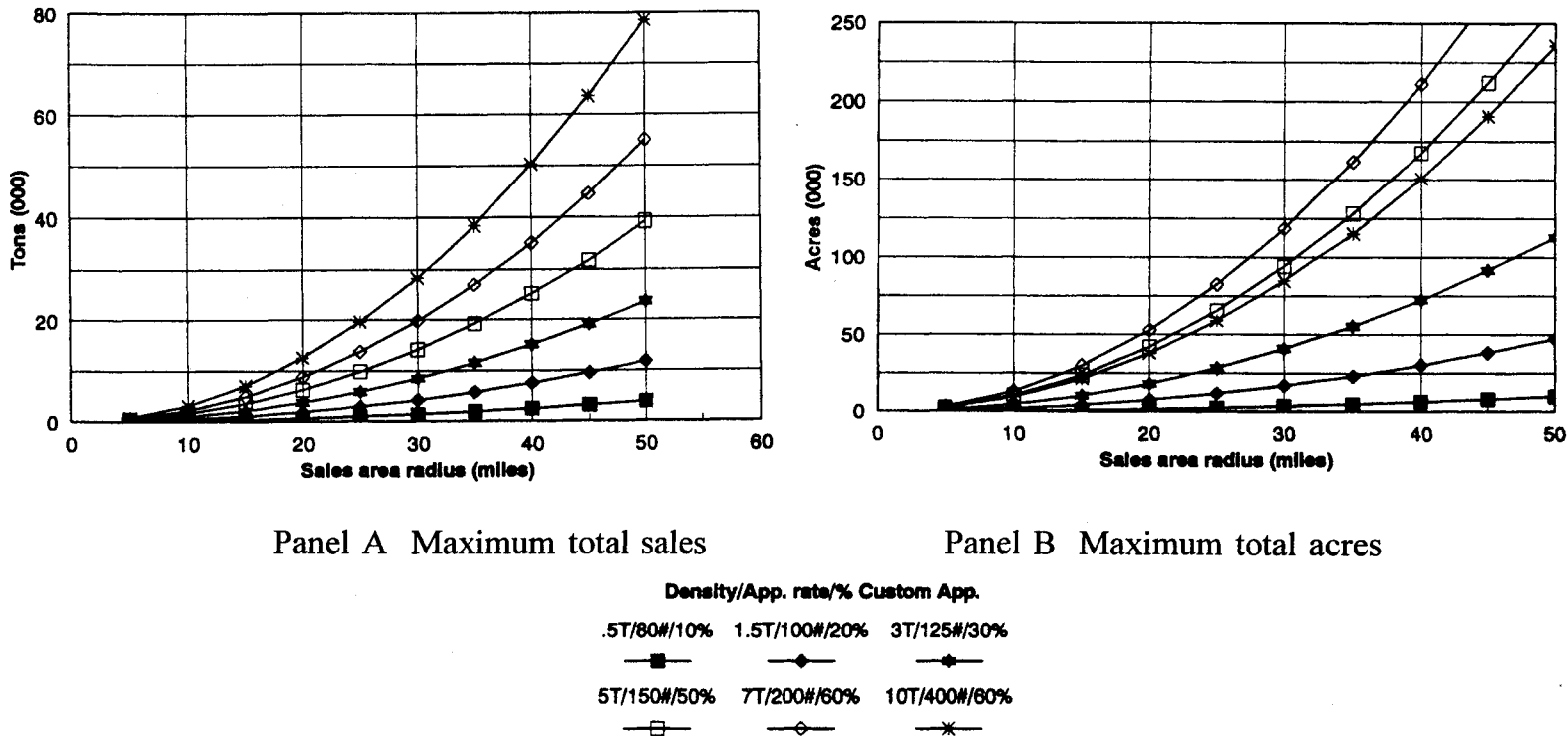


Figure 9. Maximum total sales and total acres of custom applied dry fertilizer by size of sales area at specified levels of sales density (tons/square mile), application rates (#/a), and percent custom applied.

Therefore, it would be relatively easy for firms in the high density sales areas to obtain higher inventory turnover ratios and allow them to service smaller trade areas.

Maximum acres that could be custom applied were estimated for several combinations of relevant variables. They were proportion of total sales custom applied (10, 20, 30, 50, 60, and 60%), application rate (80, 100, 125, 150, 200, and 400 lbs./a), sales densities of .5, 1.5, 3, 5, 7, and 10 tons, respectively (Figure 10, Panel B). Generally, a single firm operating in a 30-mile radius sales area with sales densities (.5 to 1.5 tons/sq. mile) and custom application rates similar to western North Dakota could custom apply up to a maximum of 3,500 to 17,000 acres. Therefore, custom application by western fertilizer cooperatives was largely constrained by the low density of sales and preference for low levels of custom application. Since acres that are custom applied were so limited, a single firm with a large sales area could service most of the custom application needs within its area while the sales of competing firms provided the would be straight sales, no custom application.

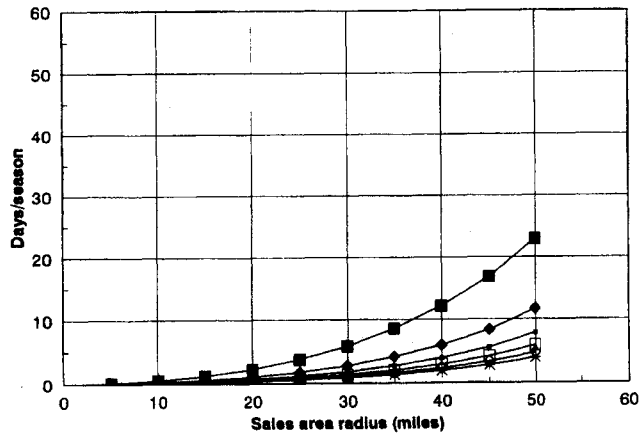
When setting the maximum acres spread equal to the maximum acres that an applicator can spread/day, a single applicator could cover a sales area of 50 miles with a sales density of .5 tons/sq. mile in about 23 14-hour days (Figure 10, Panel A). Sales areas with a radius smaller than 35 miles could be covered by a single applicator in less than 10 days.

Maximum acres for areas similar to central North Dakota (1.5 to 5 tons/sq. mile) ranged from 17,000 to 94,000 acres for a sales area 30 miles in radius. A firm in an area where the density of sales was 3 tons/sq. mile could spread all acres within a 20-mile radius or smaller in less than 27 14-hour days with one applicator (Figure 10, Panel B). Moving to higher sales density areas similar to eastern North Dakota counties, maximum acres spread for sales areas with 7 tons/sq. mile with application rates of 200 lbs./a were higher than for sales areas with 10 tons/sq. mile and 400 lbs./a application rates (Figure 10, Panels C and D).

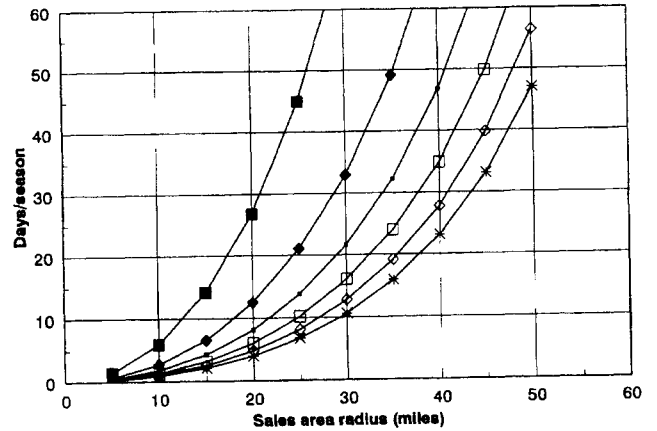
The effect of higher application rates more than offsets the increase in sales density. In these high density areas, a firm with a single applicator can service 100% of the market within a sales area of 12 miles in radius in less than 30 14-hour days. However, a firm with 6 applicators could not service a sales area with a 40-mile radius in less than 55 days. As the time required for timely application of product was reduced, the size of sales area that can be serviced was reduced. Thus, western counties are characterized by low sales densities and low custom application levels. Cooperatives in these areas can follow two strategies to achieve minimal costs. They can either employ used, older-technology equipment or seek large sales area with new technology equipment. On the other hand, higher custom application rates coupled with high sales density in eastern countries yield smaller sales area with more intense competition in response to the demand for timely application.

COST ANALYSIS

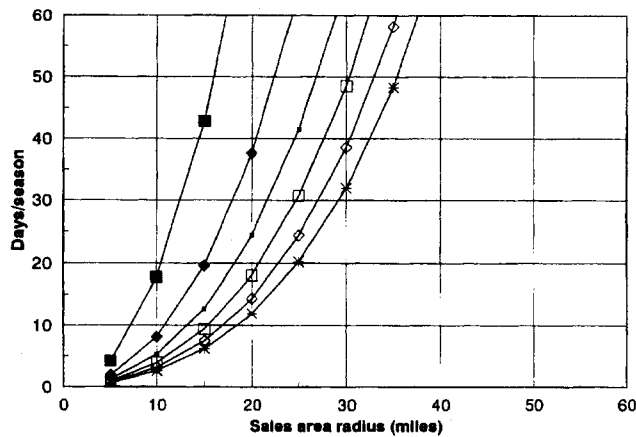
Annual costs of operation for the 6 sizes of dry fertilizer facilities were established using estimates of fixed and variable costs of operation (Table 5) and equations 5 and 7 to estimate acres applied and mileage for applicators and tender trucks developed from the



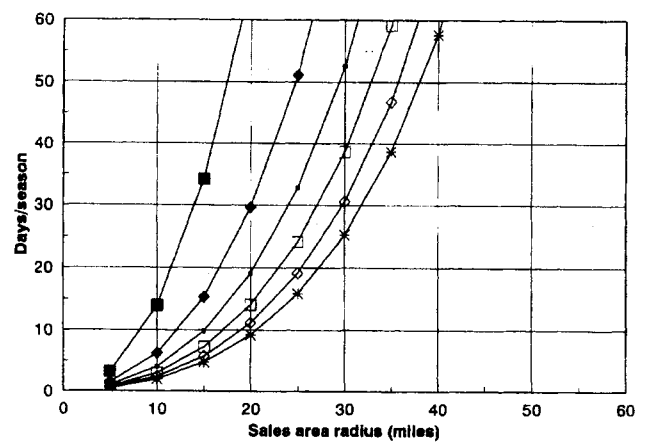
Panel A 0.5 tons/sq. mile, 80 lbs./a,
10% custom applied



Panel B 3.0 tons/sq. mile, 125 lbs./a,
30% custom applied



Panel C 7.0 tons/sq. mile, 200 lbs./a,
60% custom applied



Panel D 10.0 tons/sq. mile, 400 lbs./a,
60% custom applied

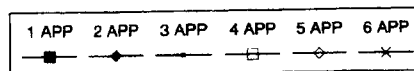


Figure 10. Number of 14-hour days required to custom apply dry fertilizer by sales area radius and specified sales/sq. mile, application rate/acre, % custom applied and number of applicators.

computer simulation model. This section of the analysis assumed a fixed proportion of total sales were custom applied with a fixed application rate, although different ranges of total sales that were custom applied and application rates were examined. First, selected categories of total costs were examined for different sales areas to determine the effect of sales area on total costs. Second, average costs were examined for various sizes of sales area and facilities to determine the effects of these factors on average total costs. Third, average total costs were examined for various fixed sales densities. This indicated the effect of increasing sales area size while maintaining a constant market share. Then, the effects of equipment combinations on average costs were examined. Costs for fertilizer facilities were not reported beyond the capacity of the custom application equipment.

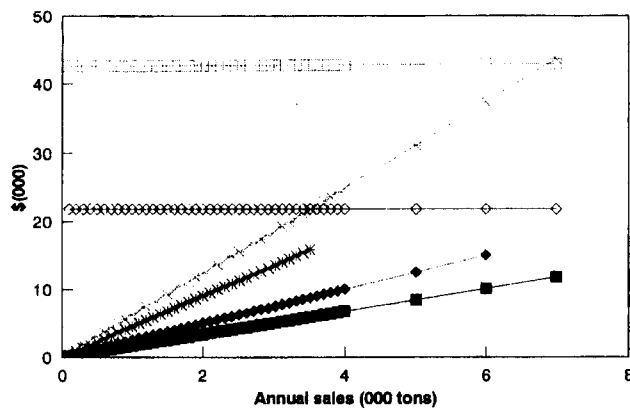
Annual Costs

Industry representatives' assessments of typical equipment configurations were used to estimate costs of operation. Total annual costs were estimated for fixed and variable costs across a range of total annual sales and sizes of sales areas. Fixed costs were classified as facility or distribution equipment costs. Variable costs separated into facility costs (variable costs not related to custom application of fertilizer) and distribution costs (costs associated with distribution and custom application of fertilizer within a fixed size of sales area). Custom application costs at optimum volumes ranged from \$10.75/ton for a 500-ton western North Dakota facility with a 5-mile radius sales area to \$40.95/ton for a 4,000-ton eastern

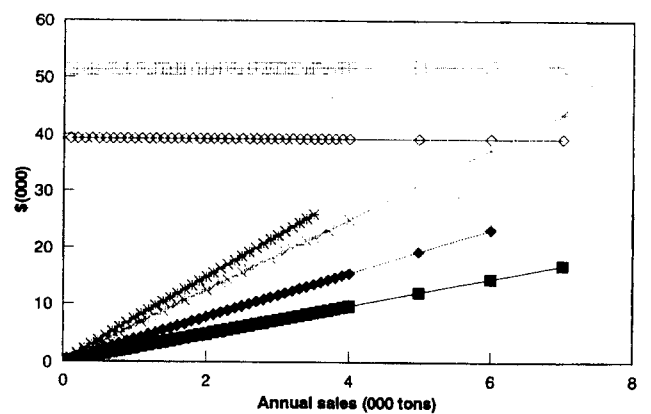
Total annual fixed costs for facilities were the largest cost for the smaller facilities throughout the range of annual sales levels examined (Figure 11). The facilities with 2,000 tons of storage had about equal amounts of fixed costs for facilities and equipment. However, the 4,000-ton facility had about twice as much fixed expenses for equipment as for facilities. Thus, for facilities representative of eastern North Dakota, fixed equipment costs became a larger share of total costs as the size of facilities increased.

Variable facility costs formed the next largest cost for the 6 sizes of facilities, followed by variable distribution costs. Variable distribution costs for a range of sales area sizes (5-20- and 50-mile radius) were minimal portions of total expenses even when approaching the capacity of the delivery equipment. Variable delivery expenses for the smallest size of sales area (5-mile radius) were within \$10,000 to \$50,000 of the costs for the same volume of sales with the largest sales area (50-mile radius). Differences in costs between the smallest and largest sales areas increased as the size of the facility increased. However, the cost difference was usually about 10% of the remaining total costs (fixed facility + fixed equipment + variable facility). This indicated that increasing the size of the sales area for cooperatives in eastern North Dakota had a minimal impact on total costs for dry fertilizer facilities.

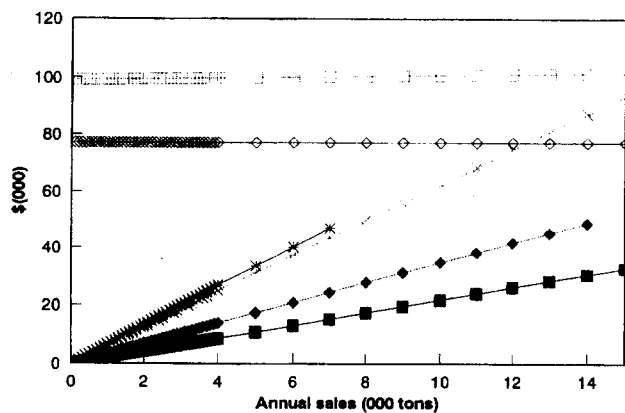
Total costs were estimated for 6 facilities with equipment complements similar to facilities in western North Dakota (Figure 12). Here, a smaller percent of total fertilizer sales were custom applied (10% versus 60% for the eastern region), and all firms had less distribution equipment. This resulted in lower fixed costs for fertilizer equipment and



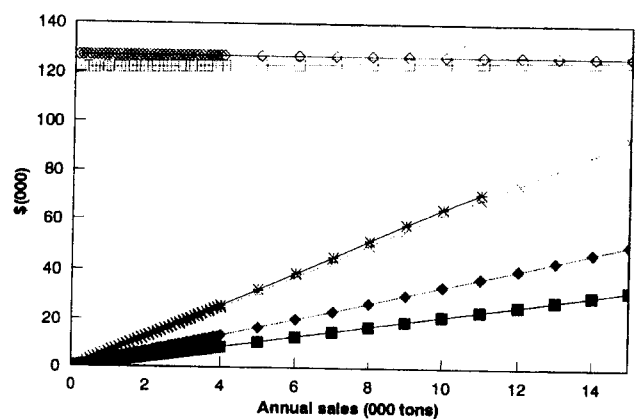
Panel A 500 ton



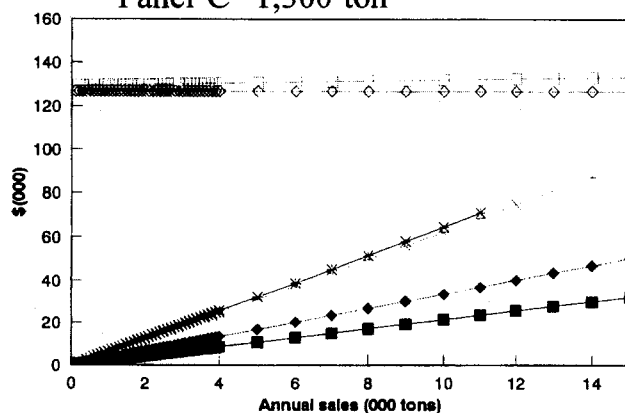
Panel B 800 ton



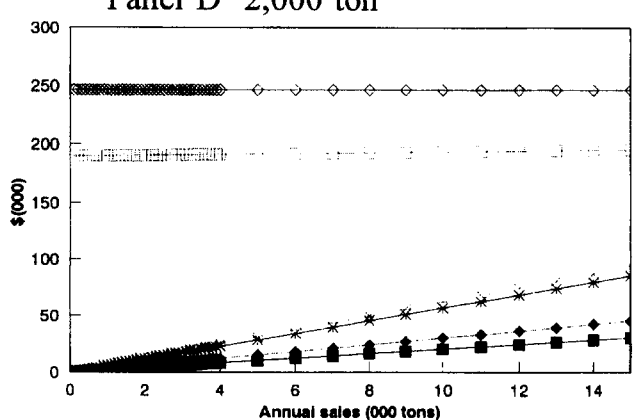
Panel C 1,300 ton



Panel D 2,000 ton



Panel E 2,000 ton w/ tower



Panel F 4,000 ton w/ tower

Var. dist. costs - 5 miles Var. dist. costs - 20 miles Var. dist. costs - 50 miles
 Fixed facility cost Fixed equipment cost Variable facility cost

Figure 11. Total annual fixed and variable costs for specified sales area radii (miles), size of facility, annual sales (\$), eastern region, North Dakota, 1992. Changes in fixed facility cost reflect assumed positive relationship between facility land values and sales density.

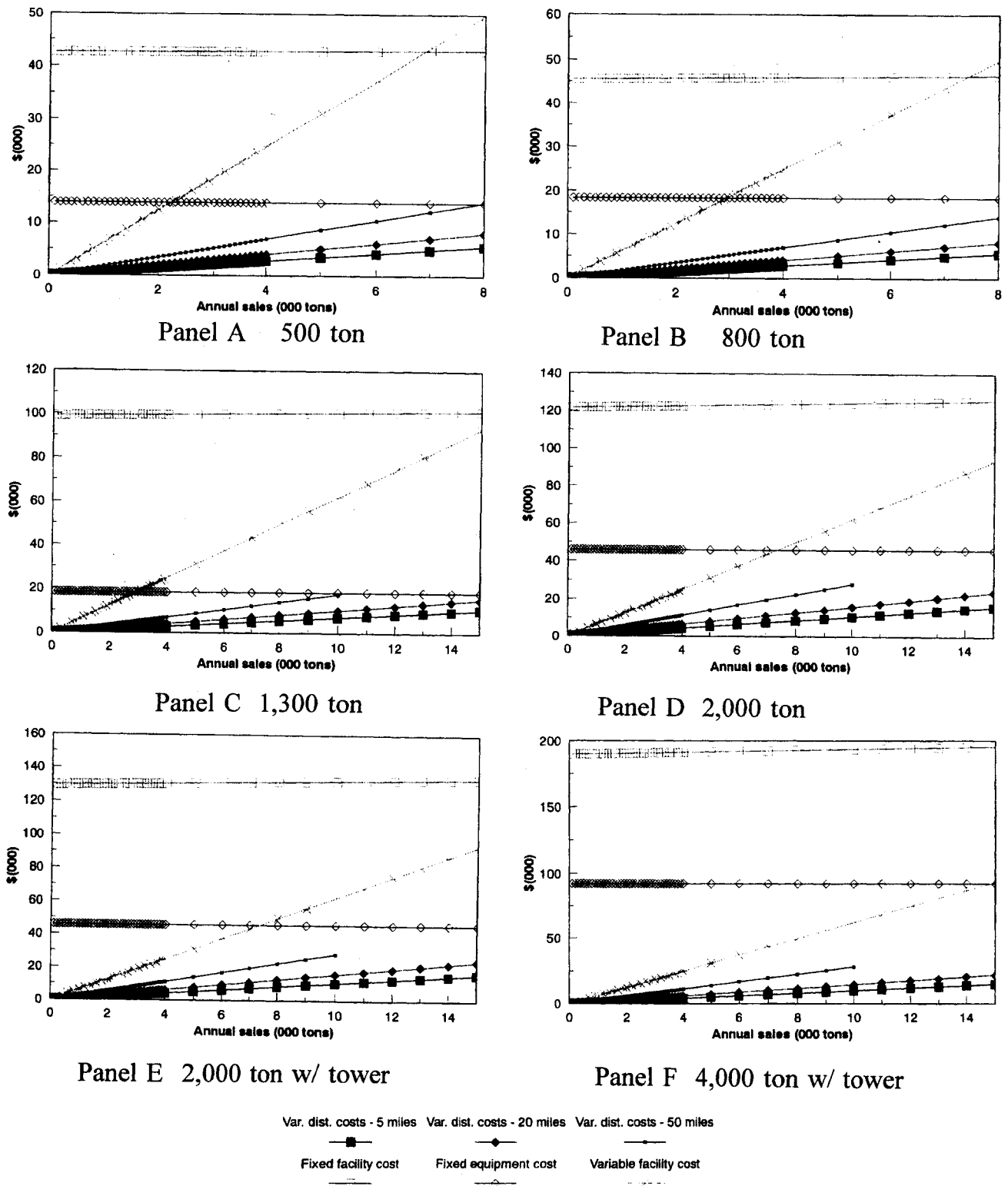


Figure 12. Total annual fixed and variable costs for selected sales area radii (miles), size of facility, annual sales (\$), western region, North Dakota, 1992. Changes in fixed facility cost reflect assumed positive relationship between facility land values and sales density.

variable costs for distribution of custom applied fertilizer than in the eastern region scenario. In fact, the total fixed costs for distribution equipment for the western region was from 20 to 50% of the total fixed costs of facilities. Total variable distribution costs were lower than for firms representing the eastern region and generally less than 15% of the remaining costs. Therefore, in western North Dakota, total fixed equipment costs influenced total costs less, and variable distribution costs were lower, but formed most of the total costs than for firms representative of eastern North Dakota.

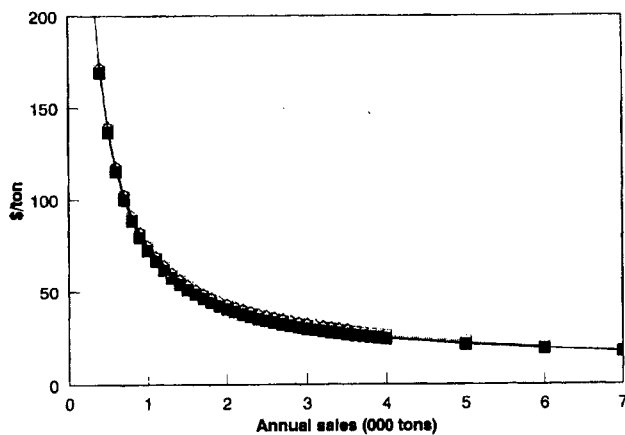
Size of Sales Area

The effect of sales area size on average costs was examined for the 6 sizes of facilities representing the eastern region of North Dakota. Average total costs were estimated for each facility with a sales area of 5, 12.5, 20, 35, and 50 miles in radius for a range of total annual sales (Figure 13). For any of the facility sizes, as the size of the sales area increased, differences in average total costs for any level of annual sales were minimal. For example, a 1,300-ton facility representative of eastern North Dakota that had annual sales of 3,000 tons/year would have an average total cost of \$67.32, \$67.83, \$68.47, \$69.90, and \$71.69/ton for 5, 12.5, 20, 35, and 50 mile radius of sales areas, respectively (Appendix Tables 1 to 5).

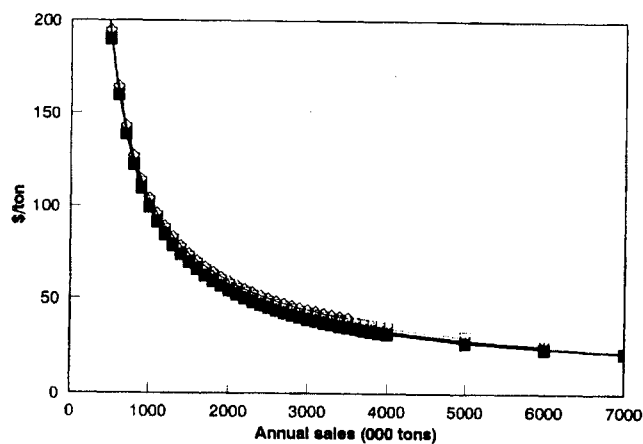
Therefore, increasing the size of the sales area serviced by a factor of 100 only increased average total costs by \$4.37/ton or 6.5%. Increasing the size of the sales area from 5 to 50 miles in radius for any level of annual sales increased average total costs by \$2.79 to \$4.88/ton for firms representative of eastern North Dakota and by only \$0.89 to \$1.49/ton for firms representative of western North Dakota (Figure 14 and Appendix Tables 1 to 5). The major impact of moving to a larger sales area was a reduction of acres that could be custom applied with a given equipment complement. This indicated that increasing the size of the sales area from a radius of 5 to 50 miles did not significantly affect average total costs for dry fertilizer cooperatives.

Size of Facility

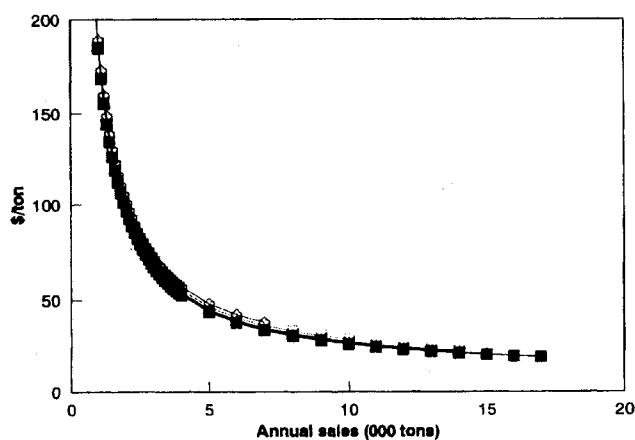
Average total costs for the 6 sizes of facilities were reexamined for each size of sales area to determine the effect of facility size on average total costs. Average total costs increased significantly as the size of facility increased (Figure 15 for eastern North Dakota and Figure 16 for western North Dakota). For example, a firm with total annual sales of 3,000 tons with a sales area of 20 miles in radius in eastern North Dakota would have average total costs of \$29.47, \$38.96, \$67.32, \$91.47, \$94.06, and \$153.83/ton for a 500-800-1,300-2,000-2,000-ton, or 4,000-ton storage facility, respectively (Appendix Table 3). Similarly, a firm in western North Dakota with total annual sales of 1,500 tons and a sales area of 35 miles in radius would have average total costs of \$45.26, \$50.19, \$85.91, \$120.03, \$125.19, and \$196.14/ton, respectively (Appendix Table 8). Therefore, in both regions, increasing the size of the storage facility and related delivery equipment impacted average total costs



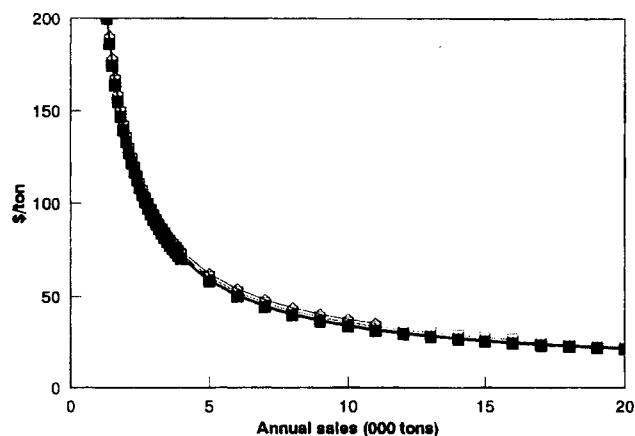
Panel A 500 ton



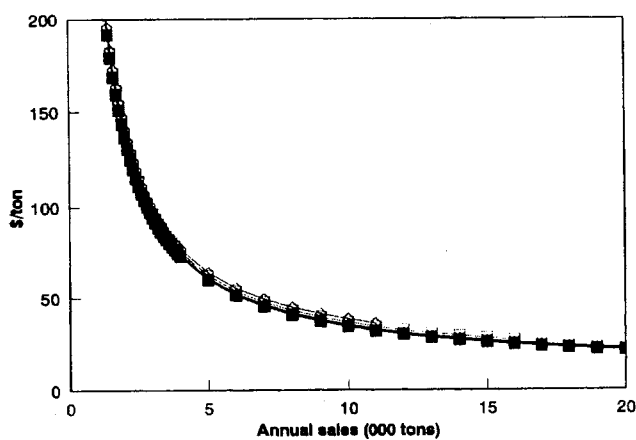
Panel B 800 ton



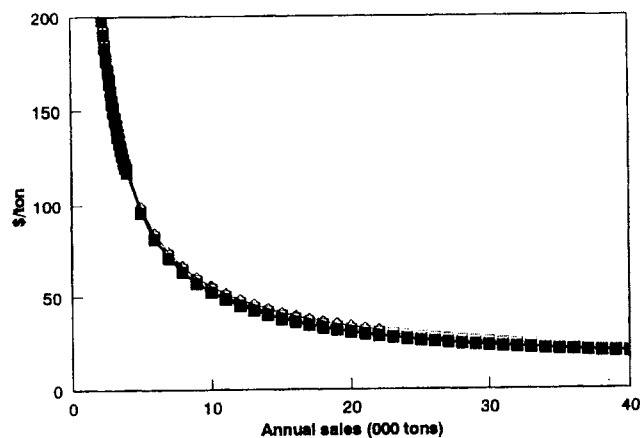
Panel C 1,300 ton



Panel D 2,000 ton



Panel E 2,000 ton w/ tower



Panel F 4,000 ton w/ tower

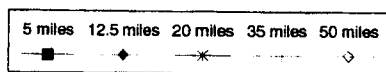


Figure 13. Average total costs by specified size of storage facility, sales area radius (miles), and annual sales, eastern region, North Dakota, 1992.

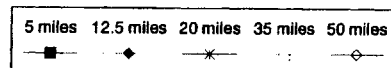
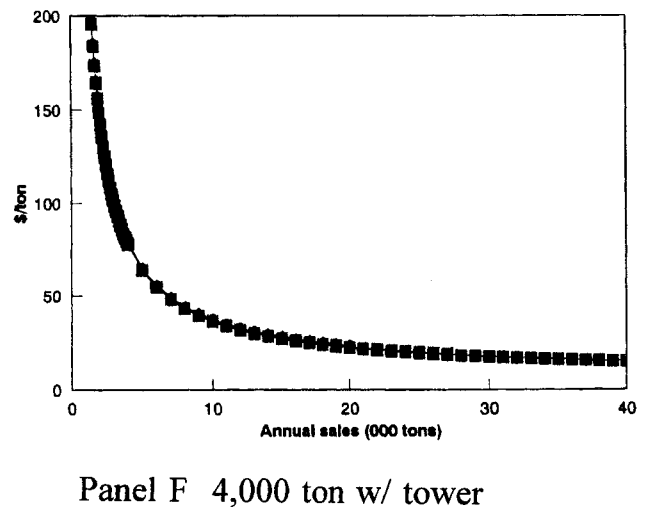
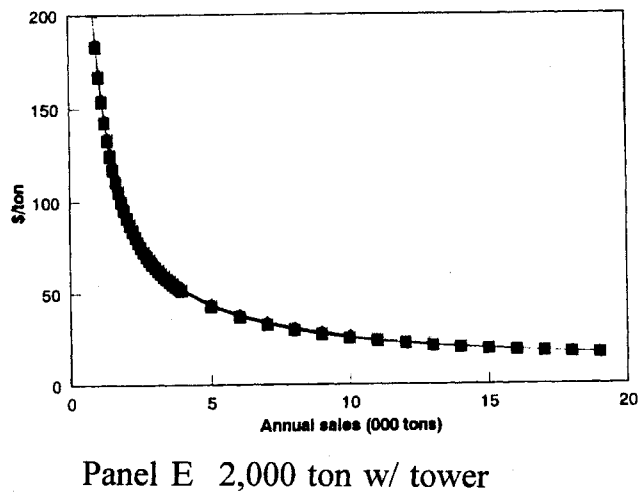
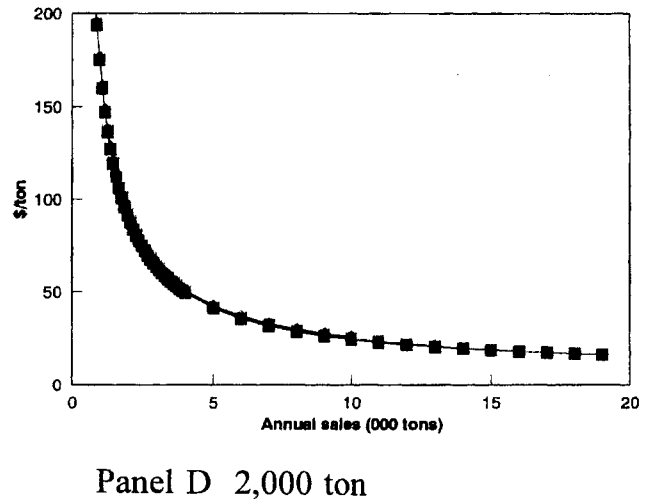
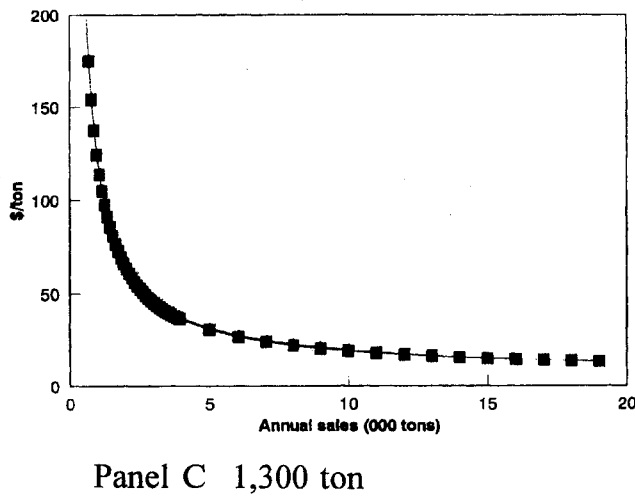
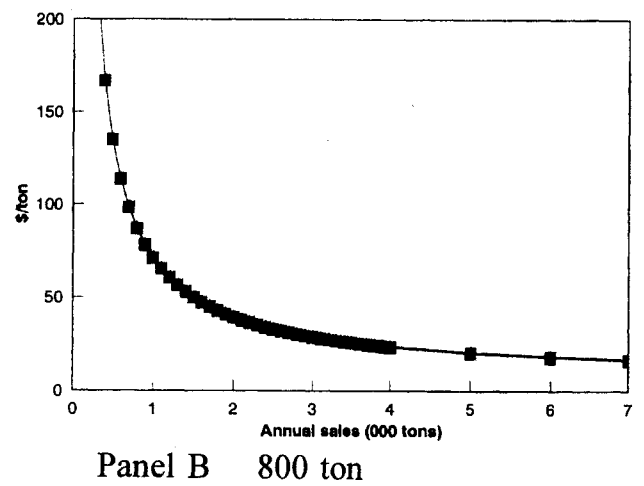
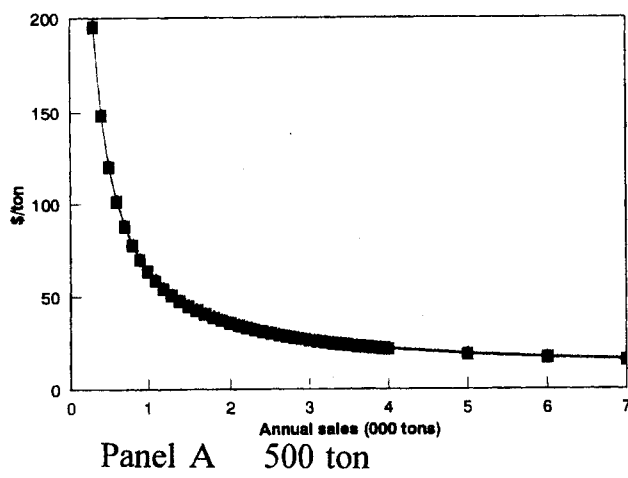
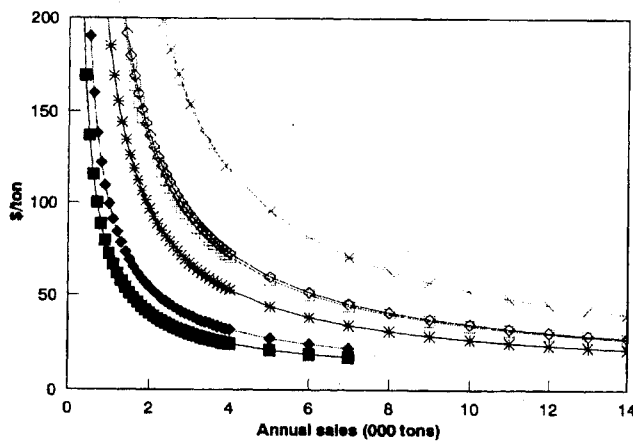
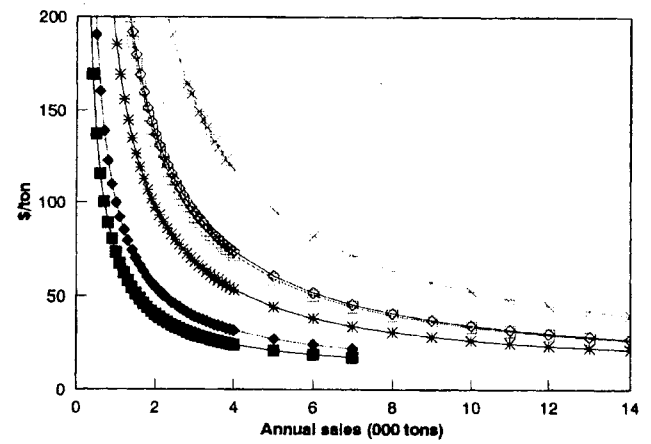


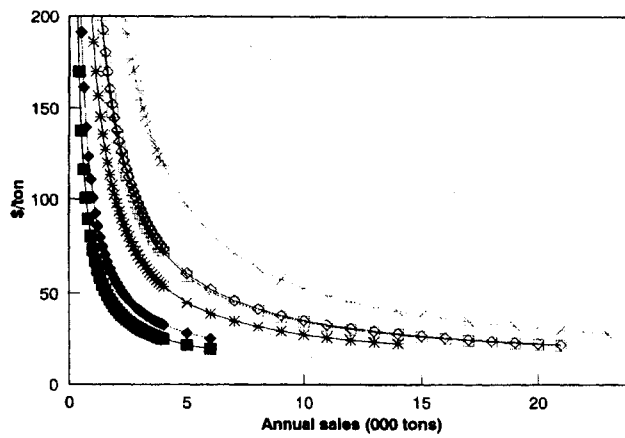
Figure 14. Average total costs by specified size of storage facility, sales area radius (miles), and annual sales, western region, North Dakota, 1992.



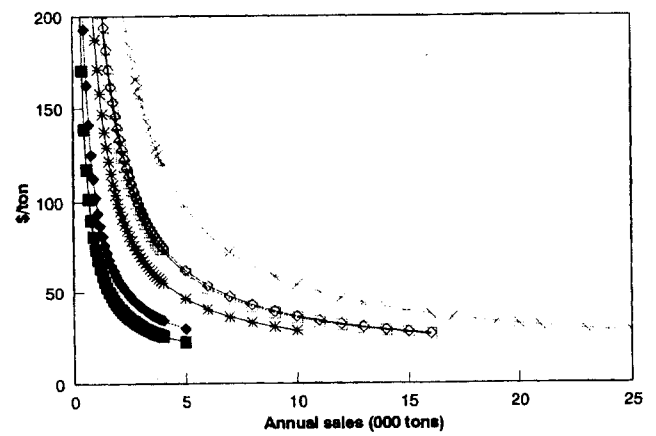
Panel A 5 mile radius



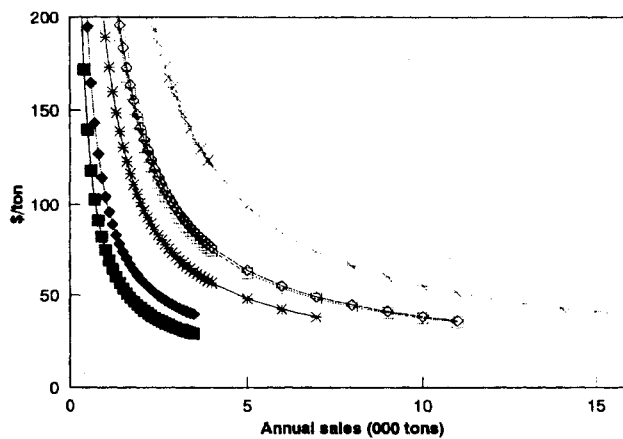
Panel B 12.5 mile radius



Panel C 20 mile radius



Panel D 35 mile radius



Panel E 50 mile radius

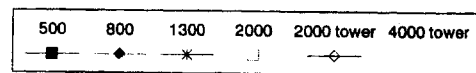
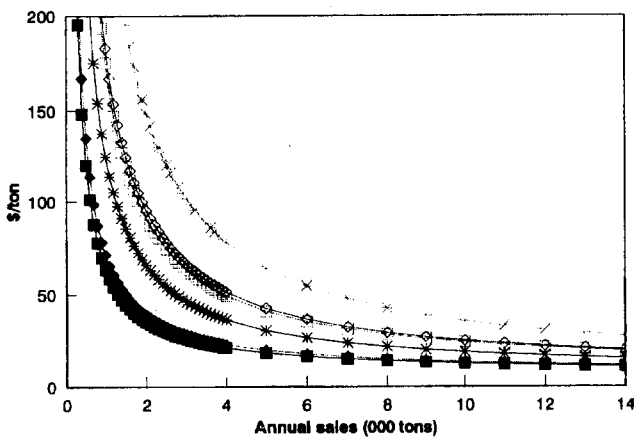
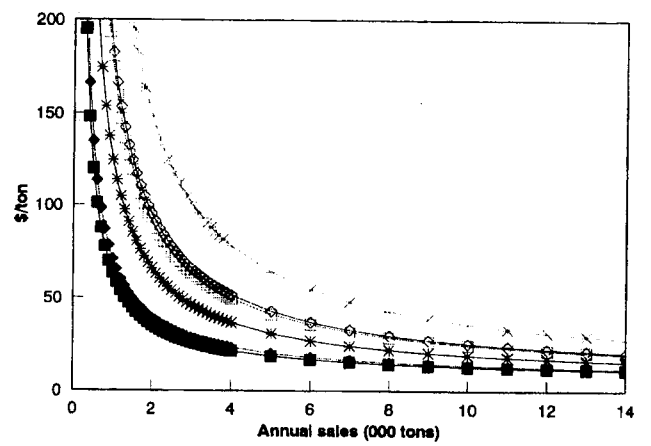


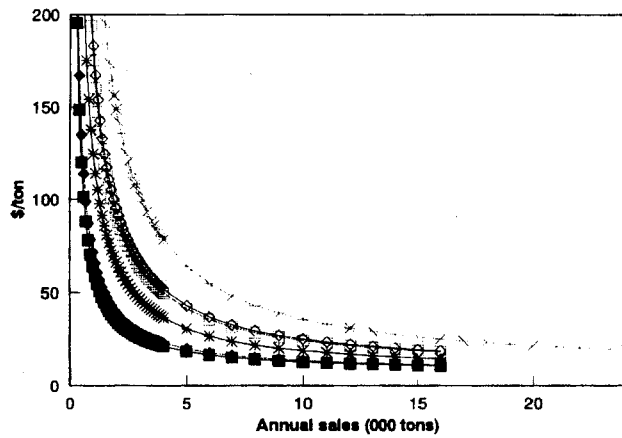
Figure 15. Average total costs for specified sales area radius, size of facility (tons) and annual sales, estern region, North Dakota, 1992.



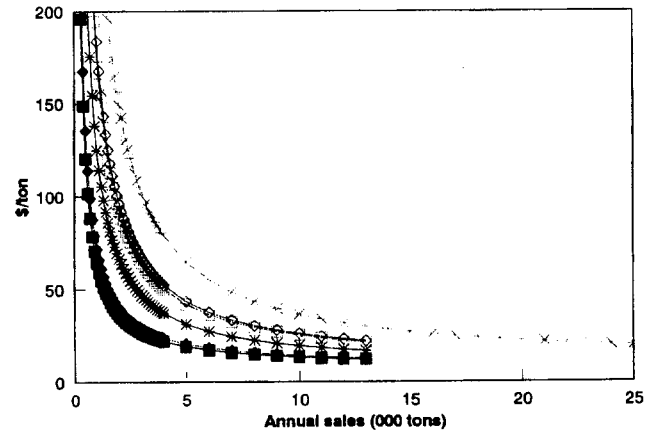
Panel A 5 mile radius



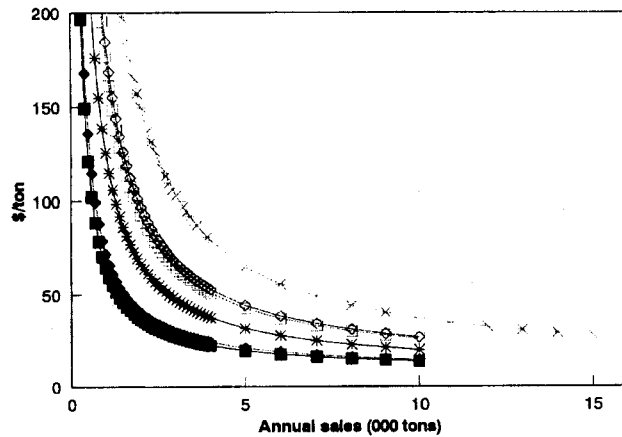
Panel B 12.5 mile radius



Panel C 20 mile radius



Panel D 35 mile radius



Panel E 50 mile radius

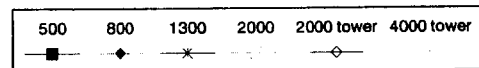


Figure 16. Average total costs for specified sales area radius, size of facility (tons) and annual sales, western region, North Dakota, 1992.

dramatically. Thus, the lowest cost facility will be the smallest facility that can operate closest to capacity.

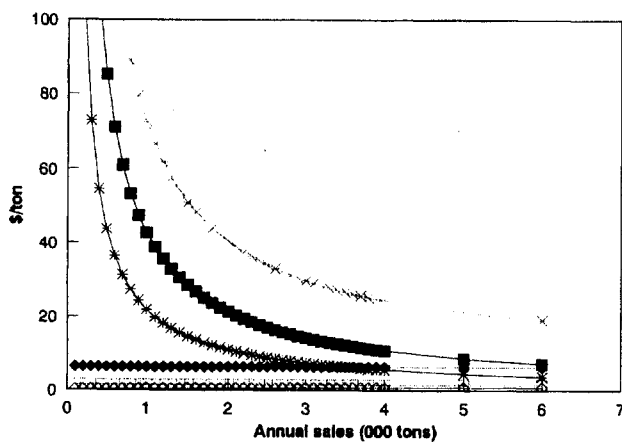
Type of Cost with Constant Sales Density

Costs were examined assuming a constant sales density. This assumed that a firm had a constant level of sales within the sales area (constant market share). Any increase in total annual sales can be achieved only by increasing the size of the sales area. Thus, this case examined costs as a firm with a given market share increased its sales area. Average costs were examined for the 6 sizes of facility using a range of sales densities common to the eastern and western regions of the state. This covered the extreme ends of sales densities in North Dakota. The eastern region scenario assumed 60% of total annual sales were custom applied, a 400 lbs./a custom application rate, a sales density of 10 tons/sq. mile, and custom application equipment complements similar to eastern North Dakota. The western region scenario assumed 10% of the total annual sales were custom applied, an 80#/a custom application rate, a sales density of .5 tons/sq. mile, and custom application equipment complements similar to western North Dakota.

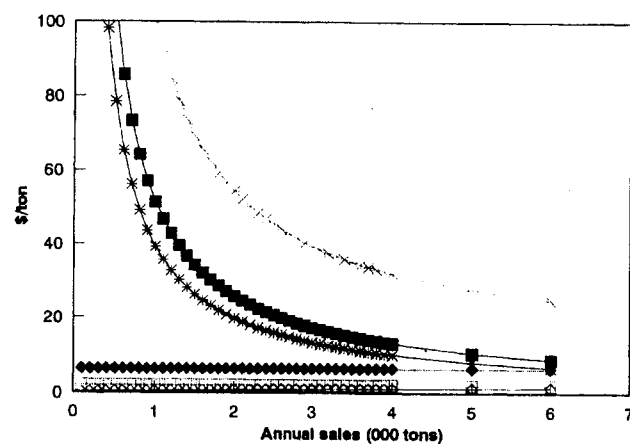
Average fixed costs for facilities formed most of the average total costs throughout the range of total annual sales examined (Figures 17 for east and Figures 18 for west). Average fixed costs for equipment and variable costs for operation of the facility were significant portions of average total costs. Average variable costs of distribution measured as costs that varied with the volume of sales and costs that varied with the radius of the sales area did not form a large portion of average total costs in either region. In fact, the capacity of the distribution equipment was reached before the variable costs of distribution could overshadow the influence of fixed facility and equipment costs on average total costs.

Average total costs for the lower sales density (.5 tons/sq. mile) representing western North Dakota were lower than for the higher sales density (10 tons/sq. mile) in eastern North Dakota (Figure 18). The difference in average total costs was due largely to a lower average fixed cost for delivery equipment due to the smaller equipment complements for the firms with the lower sales density representing western North Dakota. Average variable costs for distribution related to the size of the sales area were larger for the firms with the lower sales density, but their effect on average total cost in either region was minuscule.

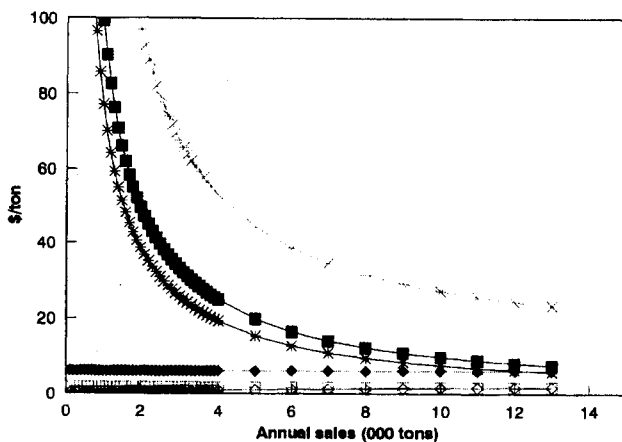
For example, a dry fertilizer facility in western North Dakota with 1,300 tons of storage, a sales density of .5 tons/sq. mile, and 2,000 tons in sales had variable distribution costs of \$1.37/ton with an average total cost/ton of \$66.35 (Appendix Table 12). Variable distribution costs for this firm were less than 2.1% of the average total costs. Alternatively, a firm with a sales density of 10 tons/sq. mile, 2,000 tons of storage with a tower, and 3,500 tons of annual sales would have variable distribution costs of \$2.59/ton and average total costs of \$82.08 (Appendix Table 11). For this firm, variable distribution costs were about 3.1% of average total costs.



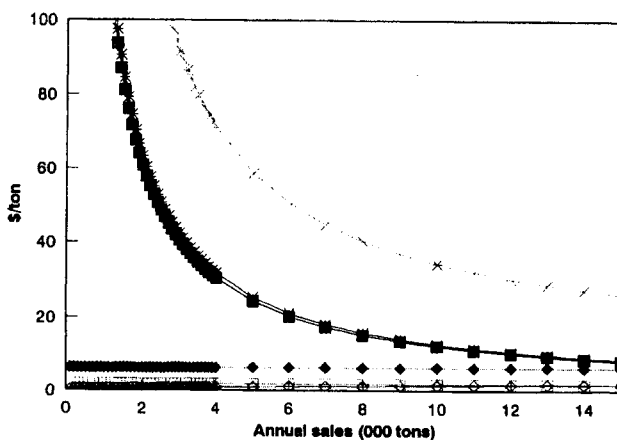
Panel A 500 ton



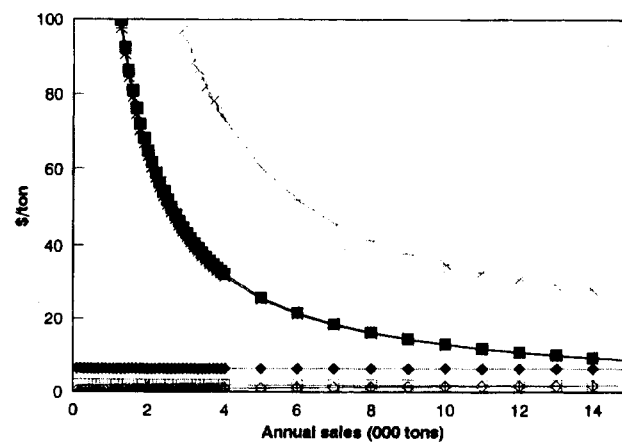
Panel B 800 ton



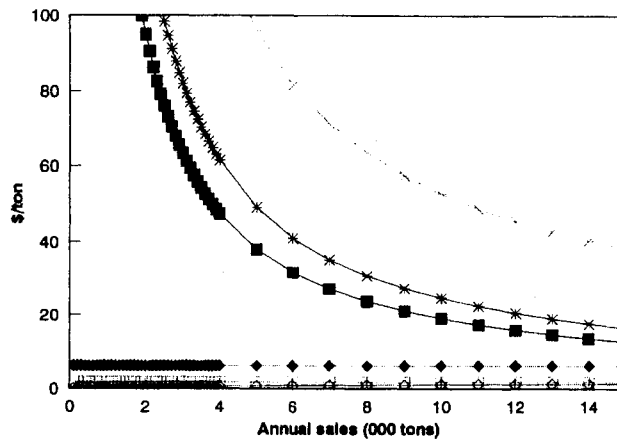
Panel C 1,300 ton



Panel D 2,000 ton



Panel E 2,000 ton w/ tower



Panel F 4,000 ton w/ tower

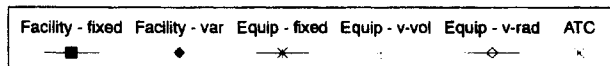
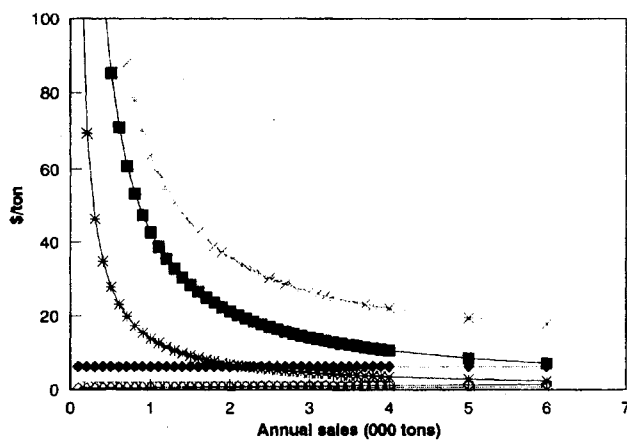
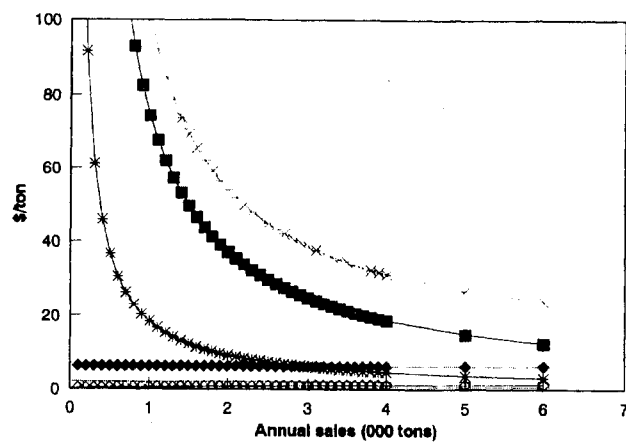


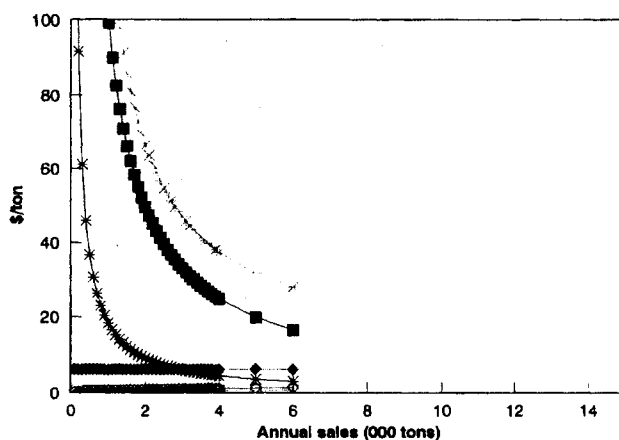
Figure 17. Average costs for custom bulk fertilizer application at specified size of storage facilities with a constant sales density of 10 tons/sq. mile, by annual sales level, eastern region, North Dakota, 1992.



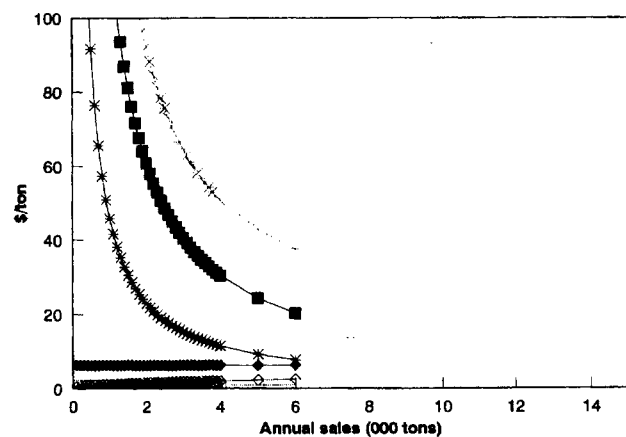
Panel A 500 ton



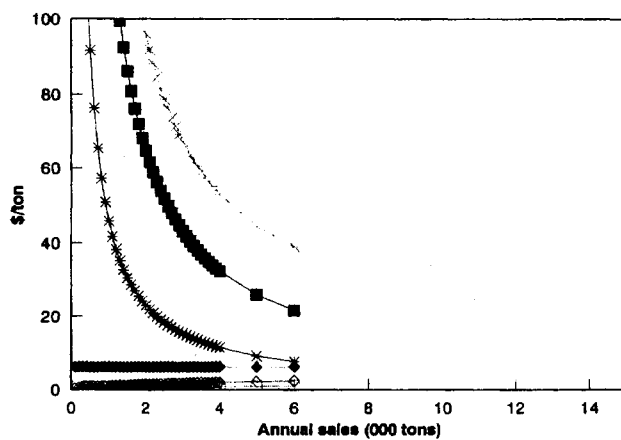
Panel B 800 ton



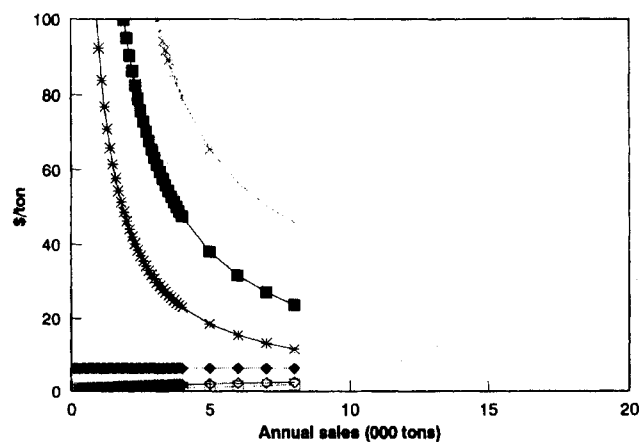
Panel C 1,300 ton



Panel D 2,000 ton



Panel E 2,000 ton w/ tower



Panel F 4,000 ton w/ tower

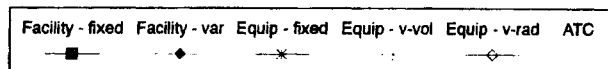


Figure 18. Average costs for custom bulk fertilizer application at specified size of storage facilities with a constant sales density of 0.5 tons/sq. mile, by annual sales level, western region, North Dakota, 1992.

These results indicated that the costs associated with increasing the size of the sales area are more than offset by the reduction in average total costs obtained with the increased sales volumes for the range of sales densities examined. The capacity of the delivery equipment is reached before cost inefficiencies of increasing the size of sales area can significantly impact average total costs in either region. Therefore, operating the smallest facilities at or near the capacity of the distribution equipment should provide the dry fertilizer facility with the lowest average total cost/ton of fertilizer sales.

Equipment Configuration

Average sizes of facilities varied across North Dakota. Two common sizes have about 1,300 tons or 2,000 tons of storage. To examine the effect of equipment compliments on average total costs for storage facilities, costs were estimated for a 1,300-ton facility with different equipment complements, sales densities, and sales areas. Average total costs were calculated for 4 situations representing different regions and cropping practices. Fertilizer application rates for these situations were 80, 125, 200, and 400#/a. Average total costs were calculated for a range of sales areas and sales densities common to each situation. Sizes of sales areas were scaled from a radius of 12.5 miles to 50 miles. Sizes of sales areas were scaled so that each increase in the radius of sales area represented a doubling in the size of the sales area (sq. miles).

Average total costs for a 1,300-ton facility with one applicator in a low density sales area (.5 tons/sq. mile) similar to western North Dakota with a 12.5-mile radius were \$488.70 per ton (Table 8). If, for example, the density of sales was increased to one or even 1.5 tons/sq. mile, increasing annual sales by a factor of 2 or 3, average total costs were reduced to \$248.25 and \$168.10, respectively. This resulted in a density cost ratio (average total cost for sales density/average total cost for base sales density) of 51% (\$248.25/\$488.70) and 34% for sales densities of one and 1.5 tons/sq. mile (Table 8). This indicated that average total costs for the sales densities of one and 1.5 tons per square mile were 51 and 34% of the costs for a sales density of .5 tons/sq. mile. Therefore, increasing the sales density by a factor of 3 for a firm with a 12.5-mile radius similar to western North Dakota resulted in average total costs/ton almost 1/3 of the average total costs of the lower sales density. A direct one-to-one relationship between percentage decreases in average total costs with increased sales would result from a firm with no or constant variable costs. This further indicated that costs for firms within these sales densities were largely dominated by fixed costs.

Similarly, a firm with a single used applicator in a sales area of 12.5 miles in radius with a sales density of one ton/sq. mile had an average total cost of \$209.68/ton. Increasing the size of the sales area to 17.7 miles in radius doubled the size of the sales area and the amount of total annual sales, reducing average total costs for a firm with a used applicator to \$108.54 or to 52% of the costs for the smaller sales area as represented by the sales area cost ratio. Therefore, doubling the size of the sales area from 12.5 miles to 17.7 miles in radius resulted in almost a halving of average total costs/ton. However, as the size of the sales area

Table 8. Average total cost, density cost ratio, and sales area cost ratios for a range of sales densities, by region/application rate and number/type of applicators, custom bulk fertilizer application, North Dakota, 1992

Sales density	Radius of sales area (miles)																	
	12.5 (Number/condition of applicators)						17.7 (Number/condition of applicators)						25 (Number/condition of applicators)					
	1 used	1	2	3	4	5/truck ¹	1 used	1	2	3	4	5/truck ¹	1 used	1	2	3	4	5/truck ¹
-----Western region - 80#/a application rate-----																		
(tons/sq. mile)	----- Average total cost (\$/ton) -----																	
0.5	411.80	488.70	589.12	809.42	928.32	379.33	209.34	247.83	297.72	407.60	466.92	193.15	109.05	128.49	153.29	208.36	238.13	100.93
0.75	277.06	328.40	395.24	542.12	621.38	255.41	142.14	167.88	201.03	274.28	313.84	131.34	75.36	88.42	104.82	141.53	161.40	69.95
1	209.68	248.25	298.30	408.47	467.92	193.45	108.54	127.90	152.68	207.63	237.30	100.44	58.52	68.38	80.58	108.12	123.03	54.46
1.25	169.26	200.16	240.14	328.27	375.84	156.27	88.38	103.92	123.68	167.63	191.38	81.90	48.41	56.36	66.04	88.07	100.01	45.17
1.5	142.31	168.10	201.37	274.81	314.45	131.49	74.94	87.93	104.34	140.97	160.76	69.54	41.68	48.34	56.35	74.71	84.67	38.97
(-	----- Density cost ratio (specified to 0.5) -----																	
0.5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.75	0.6728	0.6720	0.6709	0.6698	0.6694	0.6733	0.6790	0.6774	0.6752	0.6729	0.6722	0.6800	0.6911	0.6881	0.6838	0.6793	0.6778	0.6931
1	0.5092	0.5080	0.5064	0.5046	0.5041	0.5100	0.5185	0.5161	0.5128	0.5094	0.5082	0.5200	0.5366	0.5322	0.5257	0.5189	0.5167	0.5396
1.25	0.4110	0.4096	0.4076	0.4056	0.4049	0.4120	0.4222	0.4193	0.4154	0.4113	0.4099	0.4240	0.4440	0.4386	0.4308	0.4227	0.4200	0.4475
1.5	0.3456	0.3440	0.3418	0.3395	0.3387	0.3466	0.3580	0.3548	0.3505	0.3459	0.3443	0.3600	0.3822	0.3762	0.3676	0.3586	0.3555	0.3861
(-	----- Sales area cost ratio (specified to 1 used) -----																	
0.5	1.0000	1.1867	1.4306	1.9656	2.2543	0.9211	0.5084	0.6018	0.7230	0.9898	1.1338	0.4690	0.2648	0.3120	0.3722	0.5060	0.5783	0.2451
0.75	1.0000	1.1853	1.4266	1.9567	2.2428	0.9219	0.5130	0.6059	0.7256	0.9900	1.1328	0.4741	0.2720	0.3191	0.3783	0.5109	0.5826	0.2525
1	1.0000	1.1839	1.4226	1.9480	2.2316	0.9226	0.5176	0.6100	0.7282	0.9902	1.1317	0.4790	0.2791	0.3261	0.3843	0.5156	0.5868	0.2597
1.25	1.0000	1.1826	1.4188	1.9395	2.2205	0.9233	0.5221	0.6140	0.7307	0.9904	1.1307	0.4839	0.2860	0.3330	0.3902	0.5203	0.5909	0.2669
1.5	1.0000	1.1812	1.4150	1.9311	2.2096	0.9239	0.5266	0.6179	0.7332	0.9906	1.1297	0.4886	0.2929	0.3397	0.3959	0.5250	0.5949	0.2738
Mean	1.0000	1.1839	1.4227	1.9482	2.2318	0.9226	0.5175	0.6099	0.7281	0.9902	1.1317	0.4789	0.2790	0.3260	0.3842	0.5156	0.5867	0.2596
-----Central region - 125#/a application rate-----																		
(-	----- Average total cost (\$/ton) -----																	
1.25	168.78	199.60	239.69	327.82	375.38	454.02	87.84	103.30	123.17	167.13	190.86	230.04	47.80	55.64	65.46	87.49	99.41	118.99
2	108.15	127.47	152.45	207.53	237.26	286.40	57.60	67.33	79.66	107.13	121.97	146.44	32.64	37.61	43.65	57.42	64.88	77.08
2.75	80.59	94.68	112.79	152.86	174.48	210.20	43.86	50.97	59.88	79.87	90.66	108.44	25.75	29.41	33.74	43.75	49.19	58.03
3.5	64.84	75.94	90.13	121.61	138.60	166.66	36.00	41.63	48.58	64.28	72.77	86.72	21.81	24.73	28.07	35.94	40.22	47.15
4.25	54.65	63.82	75.47	101.40	115.39	138.49	30.92	35.58	41.27	54.20	61.19	72.67	19.26	21.70	24.41	30.88	34.42	40.10
5	47.51	55.33	65.20	87.24	99.14	118.77	27.36	31.35	36.15	47.14	53.09	62.83	17.48	19.58	21.84	27.35	30.35	35.17
(-	----- Density cost ratio (specified to 0.5) -----																	
1.25	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	0.6407	0.6386	0.6360	0.6331	0.6321	0.6308	0.6557	0.6517	0.6467	0.6410	0.6391	0.6366	0.6828	0.6759	0.6668	0.6563	0.6527	0.6478
2.75	0.4775	0.4743	0.4706	0.4663	0.4648	0.4630	0.4993	0.4934	0.4862	0.4779	0.4750	0.4714	0.5387	0.5286	0.5154	0.5000	0.4948	0.4877
3.5	0.3841	0.3805	0.3760	0.3710	0.3692	0.3671	0.4098	0.4030	0.3944	0.3846	0.3813	0.3770	0.4563	0.4444	0.4288	0.4108	0.4046	0.3962
4.25	0.3238	0.3197	0.3148	0.3093	0.3074	0.3050	0.3520	0.3444	0.3350	0.3243	0.3206	0.3159	0.4030	0.3899	0.3728	0.3530	0.3462	0.3370
5	0.2815	0.2772	0.2720	0.2661	0.2641	0.2616	0.3115	0.3035	0.2935	0.2821	0.2782	0.2731	0.3657	0.3518	0.3336	0.3126	0.3053	0.2956
(-	----- Sales area cost ratio (specified to 1 used) -----																	
1.25	1.0000	1.1826	1.4201	1.9422	2.2240	2.6900	0.5205	0.6120	0.7298	0.9902	1.1308	1.3629	0.2832	0.3297	0.3878	0.5184	0.5890	0.7050
2	1.0000	1.1786	1.4096	1.9190	2.1938	2.6482	0.5326	0.6225	0.7366	0.9906	1.1279	1.3540	0.3018	0.3478	0.4036	0.5309	0.5999	0.7127
2.75	1.0000	1.1749	1.3996	1.8968	2.1651	2.6084	0.5442	0.6325	0.7431	0.9911	1.1250	1.3456	0.3195	0.3650	0.4186	0.5429	0.6104	0.7201
3.5	1.0000	1.1713	1.3901	1.8757	2.1377	2.5705	0.5553	0.6420	0.7493	0.9915	1.1224	1.3375	0.3364	0.3814	0.4330	0.5543	0.6203	0.7272
4.25	1.0000	1.1678	1.3810	1.8555	2.1116	2.5343	0.5658	0.6511	0.7552	0.9918	1.1198	1.3298	0.3525	0.3971	0.4466	0.5652	0.6298	0.7339
5	1.0000	1.1645	1.3751	1.8420	2.0940	2.5102	0.5722	0.6554	0.7588	0.9916	1.1175	1.3245	0.3616	0.4048	0.4545	0.5712	0.6346	0.7375
Mean	1.0000	1.1714	1.3911	1.8778	2.1405	2.5743	0.5540	0.6407	0.7486	0.9913	1.1225	1.3383	0.3343	0.3792	0.4313	0.5529	0.6190	0.7263

cont'd.

Table 8. (cont').

Sales density	Size of sales area (miles)											
	35.5 (Number/Condition of applicators)						50 (Number/Condition of applicators)					
	1 used	1	2	3	4	5/truck ¹	1 used	1	2	3	4	5/truck ¹
-----Western region - 80#/a application rate-----												
(tons/sq. mile)	Average total cost (Dollars per ton)											
0.5	58.51	68.34	80.37	107.67	122.50	54.48	34.08	39.30	45.03	58.80	66.36	32.05
0.75	41.80	48.46	56.33	74.53	84.44	39.12	25.66	29.28	32.91	42.09	47.18	24.31
1	33.45	38.52	44.31	57.96	65.41	31.43	21.45	24.27	26.85	33.74	37.58	20.43
1.25	28.44	32.56	37.10	48.02	54.00	26.83	18.92	21.26	23.22	28.73	31.83	18.11
1.5	25.09	28.59	32.30	41.39	46.39	23.75	12.36	12.36	20.79	25.39	27.99	12.36
-----Density cost ratio-----												Mean
0.5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.75	0.7145	0.7092	0.7009	0.6922	0.6893	0.7180	0.7529	0.7450	0.7309	0.7159	0.7109	0.7584
1	0.5717	0.5637	0.5514	0.5383	0.5340	0.5770	0.6293	0.6176	0.5964	0.5738	0.5664	0.6375
1.25	0.4860	0.4765	0.4617	0.4460	0.4408	0.4924	0.5552	0.5411	0.5156	0.4886	0.4797	0.5650
1.5	0.4289	0.4183	0.4018	0.3844	0.3787	0.4360	0.3627	0.3145	0.4618	0.4317	0.4218	0.3856
-----Sales area cost ratio-----												
0.5	0.1421	0.1659	0.1952	0.2615	0.2975	0.1323	0.0828	0.0954	0.1093	0.1428	0.1611	0.0778
0.75	0.1509	0.1749	0.2033	0.2690	0.3048	0.1412	0.0926	0.1057	0.1188	0.1519	0.1703	0.0877
1	0.1595	0.1837	0.2113	0.2764	0.3120	0.1499	0.1023	0.1157	0.1281	0.1609	0.1792	0.0975
1.25	0.1680	0.1924	0.2192	0.2837	0.3190	0.1585	0.1118	0.1256	0.1372	0.1697	0.1881	0.1070
1.5	0.1763	0.2009	0.2269	0.2908	0.3260	0.1669	0.0869	0.0869	0.1461	0.1784	0.1967	0.0869
Mean	0.1594	0.1836	0.2112	0.2763	0.3118	0.1498	0.0953	0.1059	0.1279	0.1607	0.1791	0.0914
-----Central region - 125#/a application rate-----												
Average total cost (Dollars per ton)												
1.25	27.69	31.71	36.40	47.32	53.27	62.88	18.19	20.39	22.52	28.03	31.08	35.81
2	20.17	22.77	25.58	32.40	36.14	42.10	10.78	10.78	16.87	20.31	22.25	25.13
2.75	16.76	18.70	20.66	25.62	28.36	32.65	9.48	9.48	14.39	16.90	18.33	20.37
3.5	14.80	16.38	17.86	21.75	23.91	27.25	8.74	8.74	12.98	14.94	16.08	17.65
4.25	13.54	14.88	16.04	19.24	21.03	23.76	8.26	8.26	8.26	13.68	14.63	15.89
5	12.66	13.82	14.76	17.49	19.02	21.32	8.13	8.13	8.13	13.00	13.82	14.85
-----Density cost ratio-----												Mean
1.25	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	0.7285	0.7180	0.7028	0.6848	0.6785	0.6695	0.5926	0.5285	0.7490	0.7247	0.7158	0.7018
2.75	0.6051	0.5898	0.5677	0.5415	0.5324	0.5193	0.5214	0.4650	0.6390	0.6028	0.5896	0.5896
3.5	0.5346	0.5165	0.4906	0.4597	0.4489	0.4334	0.4807	0.4287	0.5761	0.5331	0.5175	0.4928
4.25	0.4890	0.4691	0.4406	0.4067	0.3949	0.3779	0.4544	0.4052	0.3669	0.4880	0.4708	0.4437
5	0.4570	0.4359	0.4056	0.3696	0.3570	0.3390	0.4469	0.3986	0.3609	0.4636	0.4446	0.4148
-----Sales area cost ratio-----												
1.25	0.1641	0.1879	0.2156	0.2803	0.3156	0.3726	0.1078	0.1208	0.1334	0.1661	0.1842	0.2121
2	0.1865	0.2105	0.2365	0.2996	0.3342	0.3893	0.0997	0.0997	0.1560	0.1878	0.2057	0.2324
2.75	0.2079	0.2321	0.2564	0.3180	0.3519	0.4052	0.1177	0.1177	0.1786	0.2097	0.2274	0.2527
3.5	0.2283	0.2526	0.2754	0.3355	0.3688	0.4203	0.1348	0.1348	0.2001	0.2305	0.2481	0.2722
4.25	0.2478	0.2722	0.2935	0.3521	0.3849	0.4348	0.1512	0.1512	0.1512	0.2503	0.2678	0.2907
5	0.2577	0.2809	0.3030	0.3607	0.3926	0.4424	0.1680	0.1680	0.2293	0.2585	0.2751	0.2986
Mean	0.2257	0.2497	0.2730	0.3332	0.3665	0.4184	0.1343	0.1343	0.1831	0.2274	0.2448	0.2693

cont'd.

Table 8. (cont'd).

Sales density	Radius of sales area (miles)																	
	12.5 (Number/condition of applicators)						17.7 (Number/condition of applicators)						25 (Number/condition of applicators)					
	1 used	1	2	3	4	5/truck ¹	1 used	1	2	3	4	5/truck ¹	1 used	1	2	3	4	5/truck ¹
-----Western region - 80#/a application rate-----																		
(tons/sq. mile)	----- Average total cost (\$/ton) -----)																	
5	47.20	54.96	64.90	86.94	98.83	118.48	27.01	30.94	35.81	46.80	52.74	62.51	17.07	19.10	21.45	26.96	29.95	34.81
6	40.46	46.95	55.21	73.57	83.49	99.85	23.65	26.94	30.98	40.14	45.09	53.23	15.38	17.10	19.03	23.62	26.11	30.15
7	35.65	41.22	48.29	64.03	72.53	86.55	21.25	24.08	27.52	35.38	39.62	46.59	14.18	15.67	17.30	21.23	23.37	26.83
8	32.04	36.93	43.09	56.87	64.30	76.57	19.45	21.94	24.93	31.81	35.52	41.61	13.28	14.60	16.00	19.44	21.32	24.33
9	28.97	33.28	38.80	51.05	57.65	68.57	17.75	19.94	22.64	28.75	32.05	37.48	12.24	13.37	14.67	17.73	19.39	22.09
-----Density cost ratio-----																		
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	0.8573	0.8542	0.8506	0.8463	0.8447	0.8428	0.8756	0.8708	0.8650	0.8576	0.8549	0.8514	0.9013	0.8951	0.8870	0.8761	0.8719	0.8662
7	0.7553	0.7500	0.7440	0.7365	0.7338	0.7305	0.7867	0.7785	0.7686	0.7558	0.7512	0.7453	0.8308	0.8202	0.8064	0.7875	0.7804	0.7707
8	0.6788	0.6719	0.6639	0.6541	0.6506	0.6463	0.7201	0.7093	0.6963	0.6796	0.6735	0.6657	0.7780	0.7640	0.7458	0.7211	0.7118	0.6990
9	0.6138	0.6056	0.5979	0.5872	0.5833	0.5787	0.6574	0.6445	0.6322	0.6142	0.6076	0.5995	0.7171	0.7000	0.6838	0.6576	0.6473	0.6346
-----Sales area cost ratio-----																		
5	1.0000	1.1645	1.3751	1.8420	2.0940	2.5102	0.5722	0.6554	0.7588	0.9916	1.1175	1.3245	0.3616	0.4048	0.4545	0.5712	0.6346	0.7375
6	1.0000	1.1603	1.3645	1.8184	2.0634	2.4679	0.5844	0.6658	0.7656	0.9920	1.1144	1.3155	0.3802	0.4227	0.4703	0.5837	0.6454	0.7452
7	1.0000	1.1563	1.3545	1.7961	2.0345	2.4279	0.5960	0.6756	0.7721	0.9924	1.1115	1.3069	0.3978	0.4396	0.4853	0.5956	0.6557	0.7525
8	1.0000	1.1526	1.3450	1.7749	2.0070	2.3899	0.6069	0.6848	0.7783	0.9927	1.1088	1.2988	0.4145	0.4556	0.4994	0.6068	0.6654	0.7594
9	1.0000	1.1489	1.3394	1.7620	1.9901	2.3668	0.6128	0.6882	0.7816	0.9923	1.1062	1.2936	0.4225	0.4616	0.5064	0.6120	0.6692	0.7625
Mean	1.0000	1.1565	1.3557	1.7987	2.0378	2.4326	0.5945	0.6740	0.7713	0.9922	1.1117	1.3079	0.3953	0.4368	0.4832	0.5939	0.6541	0.7514
-----Eastern region - 400#/a application rate-----																		
----- Average total cost (Dollars per ton) -----																		
8	31.78	36.62	42.84	56.62	64.05	76.33	19.15	21.60	24.66	31.53	35.24	41.35	12.94	14.21	15.68	19.12	20.99	24.03
9	28.97	33.28	38.80	51.05	57.65	68.57	17.75	19.94	22.64	28.75	32.05	37.48	12.24	13.37	14.67	17.73	19.39	22.09
10	26.73	30.61	35.57	46.59	52.54	62.36	16.63	18.60	21.03	26.53	29.50	34.38	11.68	12.71	13.86	16.62	18.11	20.54
11	24.89	28.43	32.93	42.95	48.35	57.28	15.72	17.51	19.71	24.71	27.41	31.85	11.22	12.16	13.20	15.70	17.06	19.27
12	23.36	26.60	30.73	39.91	44.86	53.05	14.95	16.61	18.61	23.19	25.67	29.74	10.84	11.70	12.65	14.95	16.19	18.21
-----Density cost ratio-----																		
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	0.9117	0.9088	0.9057	0.9016	0.9002	0.8983	0.9269	0.9229	0.9183	0.9119	0.9095	0.9064	0.9458	0.9412	0.9356	0.9272	0.9238	0.9193
10	0.8410	0.8359	0.8303	0.8229	0.8203	0.8170	0.8684	0.8612	0.8529	0.8414	0.8371	0.8315	0.9024	0.8942	0.8841	0.8689	0.8629	0.8547
11	0.7832	0.7762	0.7686	0.7586	0.7549	0.7504	0.8206	0.8107	0.7995	0.7838	0.7778	0.7702	0.8669	0.8558	0.8419	0.8213	0.8130	0.8018
12	0.7350	0.7264	0.7172	0.7049	0.7005	0.6950	0.7807	0.7687	0.7549	0.7357	0.7285	0.7192	0.8373	0.8237	0.8068	0.7816	0.7715	0.7578
-----Sales area cost ratio-----																		
8	1.0000	1.1525	1.3482	1.7816	2.0155	2.4020	0.6027	0.6798	0.7759	0.9921	1.1088	1.3011	0.4072	0.4471	0.4934	0.6017	0.6604	0.7562
9	1.0000	1.1489	1.3394	1.7620	1.9901	2.3668	0.6128	0.6882	0.7816	0.9923	1.1062	1.2936	0.4225	0.4616	0.5064	0.6120	0.6692	0.7625
10	1.0000	1.1454	1.3311	1.7434	1.9659	2.3334	0.6224	0.6961	0.7869	0.9926	1.1037	1.2865	0.4370	0.4754	0.5187	0.6217	0.6776	0.7684
11	1.0000	1.1422	1.3231	1.7256	1.9428	2.3016	0.6315	0.7037	0.7921	0.9928	1.1013	1.2796	0.4508	0.4886	0.5305	0.6310	0.6856	0.7742
12	1.0000	1.1390	1.3155	1.7087	1.9209	2.2712	0.6402	0.7110	0.7969	0.9930	1.0990	1.2731	0.4639	0.5011	0.5417	0.6399	0.6932	0.7796
Mean	1.0000	1.1456	1.3315	1.7443	1.9670	2.3350	0.6219	0.6958	0.7867	0.9926	1.1038	1.2868	0.4363	0.4748	0.5181	0.6213	0.6772	0.7682

cont'd

cont'd.

Table 8. (cont'd).

Sales density	Size of sales area (miles)											
	35.5 (Number/Condition of applicators)						50 (Number/Condition of applicators)					
	1 used	1	2	3	4	5/truck ¹	1 used	1	2	3	4	5/truck ¹
-----Eastern region - 200#/a application rate-----												
(tons/sq. mile)	Average total cost (Dollars per ton)											
5	12.16	13.26	14.30	17.03	18.53	20.88	7.93	7.93	10.82	12.20	12.99	14.09
6	11.33	12.26	13.10	15.37	16.63	18.57	7.61	7.61	7.61	11.36	12.03	12.93
7	10.73	11.55	12.24	14.18	15.27	16.92	7.39	7.39	7.39	10.77	11.34	12.10
8	8.59	8.59	11.60	13.30	14.25	15.68	7.22	7.22	7.22	10.32	10.83	11.47
9	9.53	10.15	10.71	12.22	13.05	14.36	7.08	7.08	7.08	9.49	9.92	10.54
-----Density cost ratio-----												
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	Mean 1.1290
6	0.9313	0.9250	0.9159	0.9027	0.8973	0.8894	0.9601	0.9601	0.7033	0.9315	0.9261	0.9174 1.0461
7	0.8823	0.8715	0.8559	0.8332	0.8240	0.8104	0.9316	0.9316	0.6824	0.8826	0.8734	0.8584 1.0022
8	0.7060	0.6476	0.8109	0.7810	0.7690	0.7512	0.9102	0.9102	0.6667	0.8459	0.8338	0.8142 0.9670
9	0.7839	0.7658	0.7490	0.7180	0.7045	0.6879	0.8935	0.8935	0.6546	0.7782	0.7637	0.7477 0.9517
-----Sales area cost ratio-----												
5	0.2577	0.2809	0.3030	0.3607	0.3926	0.4424	0.1680	0.1680	0.2293	0.2585	0.2751	0.2986
6	0.2799	0.3031	0.3237	0.3798	0.4109	0.4590	0.1881	0.1881	0.1881	0.2809	0.2973	0.3196
7	0.3010	0.3241	0.3433	0.3979	0.4283	0.4747	0.2072	0.2072	0.2072	0.3020	0.3182	0.3394
8	0.2680	0.2680	0.3619	0.4150	0.4447	0.4895	0.2252	0.2252	0.2252	0.3221	0.3380	0.3581
9	0.3291	0.3504	0.3697	0.4219	0.4506	0.4958	0.2445	0.2445	0.2445	0.3277	0.3423	0.3637
Mean	0.2871	0.3053	0.3403	0.3951	0.4254	0.4723	0.2066	0.2066	0.2189	0.2982	0.3142	0.3359
-----Eastern region - 400#/a application rate-----												
Average total cost (Dollars per ton)												
8	9.88	10.57	11.21	12.91	13.85	15.32	7.42	7.42	9.19	10.04	10.52	11.22
9	9.53	10.15	10.71	12.22	13.05	14.36	7.28	7.28	7.28	9.69	10.12	10.74
10	9.26	9.82	10.31	11.67	12.42	13.59	6.98	6.98	6.98	9.21	9.60	10.15
11	9.03	9.55	9.98	11.22	11.90	12.96	6.89	6.89	6.89	8.99	9.34	9.83
12	7.80	7.80	9.71	10.84	11.47	12.44	6.82	6.82	6.82	8.80	9.12	9.57
-----Density cost ratio-----												
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	Mean 1.2258
9	0.9648	0.9608	0.9553	0.9465	0.9427	0.9372	0.9822	0.9822	0.7929	0.9653	0.9620	0.9568 1.1892
10	0.9366	0.9295	0.9196	0.9038	0.8969	0.8870	0.9410	0.9410	0.7597	0.9177	0.9126	0.9044 1.1670
11	0.9135	0.9038	0.8904	0.8688	0.8595	0.8459	0.9294	0.9294	0.7503	0.8950	0.8877	0.8761 1.1582
12	0.7894	0.7383	0.8660	0.8396	0.8282	0.8116	0.9197	0.9197	0.7425	0.8761	0.8670	0.8525 1.1483
-----Sales area cost ratio-----												
8	0.3110	0.3325	0.3528	0.4064	0.4357	0.4822	0.2334	0.2334	0.2891	0.3160	0.3310	0.3531
9	0.3291	0.3504	0.3697	0.4219	0.4506	0.4958	0.2514	0.2514	0.2514	0.3346	0.3492	0.3706
10	0.3463	0.3675	0.3858	0.4367	0.4647	0.5086	0.2611	0.2611	0.2611	0.3448	0.3591	0.3798
11	0.3627	0.3837	0.4011	0.4508	0.4782	0.5209	0.2769	0.2769	0.2769	0.3611	0.3752	0.3950
12	0.3340	0.3340	0.4157	0.4642	0.4910	0.5325	0.2920	0.2920	0.2920	0.3767	0.3904	0.4096
Mean	0.3366	0.3536	0.3850	0.4360	0.4640	0.5080	0.2630	0.2630	0.2741	0.3466	0.3610	0.3816

¹ Represents 1 used truck applicator in the Western Region and 5 applicators in all other regions.

expanding from 35.5 to 50 miles in radius would reduce costs to 64% of previous average total costs (\$21.45/\$33.45). Therefore, a firm with a small sales area that doubled sales by increasing the size of their sales area could reduce its average total costs more than a firm starting with a large sales area.

The effect of different custom application equipment complements on average total costs across sales densities and sales areas was examined. A firm representative of the central regions of North Dakota with a 1,300-ton storage facility, density of sales of 3.5 tons/sq. mile, and a 12.5-mile radius sales area (1,718 tons of annual sales, Table 9) would have average total costs of \$64.84/ton with one used applicator. If the firm moved to a new applicator, average total costs would increase to \$75.94/ton. Adding more applicators with like increases in the number of tender trucks would increase the acres that could be applied/season and the ability of firms to custom apply acres on a more timely basis. However, additional applicators and tenders would increase average total costs to \$90.13, \$121.61, \$138.60, and \$166.66 per ton for 2, 3, 4, and 5 applicators, respectively. Therefore, moving from a used to a new applicator in this situation will increase costs by \$11.10/ton or 17.13% as represented by the sales area size ratio (Table 8). Moving to 2, 3, 4, or 5 applicators would increase average total costs to 139, 188, 214, and 257% of the costs of a used applicator, respectively.

The average total cost for a firm with one new applicator for a specified sales area was 118% or less of the average total costs of a firm with a used applicator. Increasing the custom application equipment to 2, 3, 4, and 5 applicators with similar increases in tender trucks generally increased costs to less than 143, 194, 223 and 257% of the costs of a used applicator. As the size of sales area or sales density increased, the effect of increasing the size of equipment complement on average total costs decreased.

Increasing the size of the sales area and changing the custom application complement was examined. Doubling sales by moving from a 12.5-mile radius sales area to a 17.7-mile radius sales area for firms with sales densities of 3.5 tons/sq. mile reduced average total costs from \$64.84 to \$36.00/ton (Table 8). However, doubling sales and increasing the number of applicators to 2, 3, 4, or 5 changed average total costs to \$48.58, \$64.28, \$72.77, and \$86.72. Therefore, doubling annual sales by doubling the size of the sales area and increasing the number of applicators to 2, 3, 4, or 5 changed average total costs to 74.94, 99.15, 112.24, and 133.75% of the average total costs of the configuration for the smaller sales area.

IMPLICATIONS

The results of this study indicated that the least cost facility for local cooperatives would be the smallest facility and delivery equipment complement that they could operate at or near capacity. This implied that firms looking to lower costs should focus on increasing annual sales volumes or lowering fixed costs. However, since investments in facilities were largely sunk costs, firms may have little alternative but to focus on increasing sales or on some form of consolidation.

Table 9. Total annual sales within a sales area by radius of sales area and density of sales.

Sales density	Radius of sales area (miles)				
	12.5	17.7	25	35.5	50
(tons/sq. mile)	------(tons)-----				
0.5	245	492	982	1,980	3,927
0.75	368	738	1,473	2,969	5,890
1	491	984	1,963	3,959	7,854
1.25	614	1,230	2,454	4,949	9,817
1.5	736	1,476	2,945	5,939	11,781
2	982	1,968	3,927	7,918	15,708
2.75	1,350	2,707	5,400	10,888	21,598
3.5	1,718	3,445	6,872	13,857	27,489
4.25	2,086	4,183	8,345	16,827	33,379
5	2,454	4,921	9,817	19,796	39,270
6	2,945	5,905	11,781	23,755	47,124
7	3,436	6,890	13,744	27,714	54,978
8	3,927	7,874	15,708	31,674	62,832
9	4,418	8,858	17,671	35,633	70,686
10	4,909	9,842	19,635	39,592	78,540
11	5,400	10,827	21,598	43,551	86,394
12	5,890	11,811	23,562	47,510	94,248

Size of Facility

The potential risk of receiving inadequate bulk fertilizer from suppliers was a motivation for larger storage facilities. Since fertilizer usage tended to be highly seasonal, transportation of fertilizer to the individual cooperatives can at times be problematic. The highest demand for fertilizer occurred in the springtime when flooding can limit barge shipments of fertilizer. Therefore, firms needing more product during the season may not be able to obtain it in a timely manner due to unforeseen obstacles. More predictable factors leading to large storage facilities are multiple rail car and barge shipment rates and purchase quantity discounts. Also a few storage facilities are located on roads where spring road limit weight restrictions apply. Thus, local firms may consider constructing larger storage facilities than otherwise would be needed as a response to this risk. Regional fertilizer supply cooperatives wanted local cooperatives to have larger storage capacities to reduce stress on the

delivery system and to allow for more reliable service to local patrons during peak demand times.

However, other factors should be considered in deciding the size of a facility to build. Storage facilities are constructed with an expected life of 30 years or more. Thus, firms must assess future fertilizer needs and availability of product throughout the season many years in the future. Furthermore, future federal and state regulations on pollution control for catchment containment and dust control will impact facilities to various degrees. Firms with the largest sales can spread these costs out over more volume, limiting their effect on profitability more than firms with low sales volumes.

Consolidation

Considerable overlapping of sales areas exists in North Dakota (Figure 5). Overlapping sales area may be healthy for competition among investor-oriented firms. However, this situation may also represent unnecessary duplication of facilities and equipment for cooperatives. Cooperatives desiring increased levels of sales to reduce costs may consider consolidation of firms when two or more cooperatives have overlapping or adjoining sales areas and neither is operating at or near capacity. For example, two firms operating in a region similar to eastern North Dakota with 1,300 tons of storage each, sales areas 20 miles in radius, and annual sales of 3,000 tons would have average total costs of \$68.47/ton (Appendix Table 3). If consolidation resulted in a sales area that was 35 miles in radius, a single firm could supply 6,000 tons of annual sales at a cost of \$40.52 (Appendix Table 4). This would result in annual savings of \$27.95/ton or \$166,800/year. Most of these annual cost savings come from eliminating one of the firms' manager, office, and facility labor (\$76,936 or \$12.82/ton), custom application equipment (\$77,151 or \$12.86/ton), and, to a limited extent, the storage facility (\$22,425 or \$3.74/ton). However, delivery costs would increase slightly because the larger sales area would offset some of these savings.

Similarly, 2 firms representative of firms in the western region of North Dakota with 800-ton storage facilities, sales areas of 20 miles in radius, and annual sales of 1,000 tons/year would have average total costs of \$71.15/ton (Appendix Table 8). If, after consolidation, a single firm could supply 2,000 tons of annual sales within a 35-mile radius (more than twice the area of the smaller sales area) at an average total cost of \$39.54/ton (Appendix Table 9). This is an annual cost savings of \$31.61/ton or \$63,220/year. Again, most of the annual cost savings would come from eliminating one of the firm's manager, office, and facility labor (\$27,914 or \$13.96/ton), custom application equipment (\$18,348 per year or \$9.17/ton), and storage facility (\$16,886 or \$8.44/ton).

Firms considering consolidation could recover some investment in facilities and custom application equipment besides savings in annual costs of operation. The extent that investment costs are recovered will vary with the type, condition, and demand for facilities and equipment. Cost recovery could range from a value approaching original investment

value to even a negative value if facilities and/or equipment have to be abandoned. Costs for site cleanup may be required if facilities are abandoned, especially for facilities located on leased land.

Cost recovery after consolidation and site cleanup can vary widely from situation to situation. Therefore, simple payback periods were calculated for recapture of a range of the initial investment costs associated with a consolidation. This was done for various levels of annual cost savings for a 1,300-ton facility representative of eastern North Dakota (Figure 19, Panel A; Table 10). For example, if two firms consolidated and obtained annual cost savings of \$25/ton, it would take 2.36 years to recover 60% of the initial investment costs for facilities and equipment. If the firms had to recover 80 or 100% of the investment in land, facilities, and equipment, it would take 3.2 and 3.9 years, respectively. If cost savings were only \$10/ton, it would take 5.9 and 9.9 years to recover the 60% or 100% of the original investment costs for the storage facility, equipment, and land, respectively.

Years to payback were calculated for various levels of initial investment in land, storage facility, and equipment for 2 firms consolidating 800-ton facilities representative of

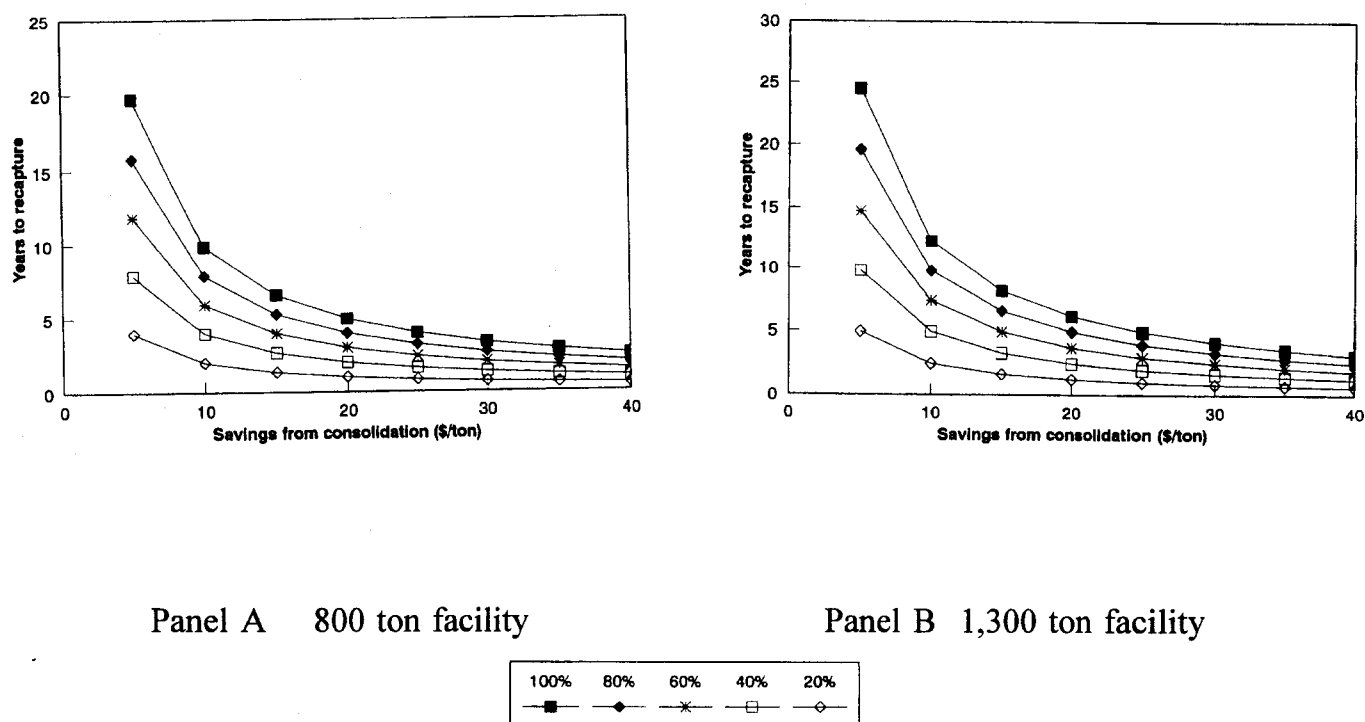


Figure 19. Pay back period for 2-firm consolidation on recovered book value of assets for 800 and 1,300 ton facilities, North Dakota, 1992. Source: Appendix Table 10.

Table 10. Payback period for 2 firm consolidation on unrecovered book value of assets, (assuming a 1,300 ton facility and associated delivery equipment at specified annual per ton cost savings), North Dakota, 1992.

Annual savings* (\$/ton)	Percent of initial investment to be recovered				
	100%	80%	60%	40%	20%
(- - - - - Western Region (800 ton) - - - - -)					
5	24.52	19.62	14.71	9.81	4.90
10	12.26	9.81	7.36	4.90	2.45
15	8.17	6.54	4.90	3.27	1.63
20	6.13	4.90	3.68	2.45	1.23
25	4.90	3.92	2.94	1.96	0.98
30	4.09	3.27	2.45	1.63	0.82
35	3.50	2.80	2.10	1.40	0.70
40	3.07	2.45	1.84	1.23	0.61
(- - - - - Eastern Region (1,300 ton) - - - - -)					
5	19.70	15.76	11.82	7.88	3.94
10	9.85	7.88	5.91	3.94	1.97
15	6.57	5.25	3.94	2.63	1.31
20	4.93	3.94	2.96	1.97	0.99
25	3.94	3.15	2.36	1.58	0.79
30	3.28	2.63	1.97	1.31	0.66
35	2.81	2.25	1.69	1.13	0.56
40	2.46	1.97	1.48	0.99	0.49

* From consolidation.

western North Dakota (Figure 19, Panel B; Appendix Table 11). If, by consolidating, annual costs of operation were reduced by \$25/ton for annual sales of 2,000 tons, the consolidated firm should recover 60% of the original investment for one firm's storage facility, land, and equipment in 2.9 years. Increasing the investment recaptured to 100% of the initial investment increased years to payback to 5 years. Therefore, limited savings in costs of operation from consolidations can recapture much of the initial investment of eliminated facilities and equipment.

As dry fertilizer cooperatives approach the capacity of their delivery equipment or consider consolidation of facilities, other factors should be considered. Farmer patrons may have to wait to get fields applied if the cooperative operated at near capacity of custom application equipment. Therefore, farmers requiring timely application may switch sales to competing firms. Further, not all annual sales of fertilizer are custom applied. If consolidation eliminated a facility, then farmers may have to drive farther to pick up fertilizer.

These farmers may choose to purchase from competing firms that are closer rather than driving to the consolidated firm or they may choose custom delivery to their farm or fields. However, a consolidated cooperative could afford to offer more favorable prices that could offset the inconvenience and cost of a longer drive. If farmers wanted custom delivery in significant numbers, firms would have to incur costs for purchase, operation, and maintenance of additional tender trucks. Preliminary results from other research suggest that ground water containment regulations will require investment of \$150,000 or more at each plant. These costs are an additional incentive for consolidation.

SUMMARY AND CONCLUSIONS

Preliminary results from other research suggest that ground water containment regulations will require investment of \$150,000 or more at each plant. These costs are an additional factor to consider consolidation. This study was undertaken to evaluate the least-cost configuration of equipment and facilities in relation to sales area size, sales density, and total sales. An economic-engineering cost approach was used to analyze these relationships. Bench-mark statistics for operating conditions were taken from personal interviews conducted with the management of 13 selected dry fertilizer cooperatives representative of the range of dry fertilizer cooperatives across North Dakota and field representatives of regional fertilizer cooperatives to gather information on general operating characteristics of dry fertilizer facilities in the state.

Costs for construction and operation of a range of sizes of facilities and custom application equipment pertinent to North Dakota were gathered from firms familiar with fertilizer facility construction, equipment suppliers, and industry representatives. Six sizes of storage facilities were examined: 500, 800, 1,300, 2,000, 2,000 ton with tower, and 4,000 ton with tower storage facilities. Annual costs of operation for custom application were estimated by gathering costs for tender truck and applicator costs on a per mile basis. Tender mileage, applicator miles, and acres applied/day were estimated using a computer simulation model.

Fixed costs dominated total costs across the range of sales volumes examined for all sizes of facilities representative of eastern and western North Dakota. This indicated that the least cost dry fertilizer facility for any sales volume was the smallest facility that could maintain liquidity of supplies within the season and that could operate at or near the capacity of their custom application equipment.

Costs reported for western and eastern North Dakota were not directly comparable because of the effort made to make costs represent operating characteristics in these two areas of the state. Characteristics reflected in these costs were sales density (lower in the west than in the east), fertilizer application rates (about 80 lbs./a in the west and up to 400 lbs./a in the east), and percent of fertilizer custom applied as opposed to farmer pick up (about 10% in the west compared to about 60% in the east). Furthermore, western North Dakota cooperatives tended to have used application equipment. The lower percent of total sales that were custom

applied and the lower application rates and used equipment explained why average costs representing western North Dakota, in spite of larger sales areas, were lower than those representing eastern North Dakota. Operating conditions in central North Dakota are about halfway between these two extremes.

Custom application costs at optimum volumes ranged from \$10.75/ton for a 500-ton western North Dakota facility with a 5-mile radius sales area to \$40.95/ton for a 4,000-ton eastern North Dakota facility with a 50-mile radius sales area. For firms representative of eastern North Dakota, fixed delivery equipment costs became a larger percent of total costs as the size of the facility and equipment compliments got larger. In fact, for facilities of 2,000 tons or more, total fixed equipment costs were larger than fixed costs for facilities. This finding did not hold for firms representative of western North Dakota where fixed costs for equipment were generally less than 50% of fixed costs for facilities. Since acres that can be custom applied/applicator declined as the size of sales area increased and fixed equipment costs were such a large portion of total costs, the capacity of the custom application equipment became one of the major determining factors of how large a facility and custom application equipment complement local facilities should operate.

Variable distribution costs did not affect average total costs significantly for sales areas with a radius less than 50 miles. Increasing the size of the sales area from 5 to 50 miles in radius for any level of annual sales increased average total costs by \$2.79 to \$4.88/ton for firms representative of eastern North Dakota and by only \$0.89 to \$1.49/ton for firms representative of western North Dakota. Similarly, for a firm expanding its sales area while maintaining a constant sales density (market share), the increased costs associated with larger sales area were more than offset by the reduction in average fixed costs obtained with the increased sales. This finding held for the range of sales densities examined. Therefore, the capacity of the delivery equipment was reached before cost inefficiencies of increasing the size of the sales area could significantly impact average total costs. The major impact of moving to a larger sales area for any sales density or sales volume was a reduction of acres that could be custom applied with a given equipment complement. Thus, in the western regions of the state, smaller firms opted for lower cost, older technology equipment when they had a small number of acres to custom apply. As the firms got larger and could operate custom application equipment near capacity, they supported newer and higher cost equipment.

As the applicator equipment compliment was upgraded from one used to 1, 2, 3, and 4 new ones, average total costs for fertilizer sales and custom application increased 118, 143, 194, and 223%, respectively, of the costs for a custom application for the smallest sales area. Costs for a used truck were 92% of a used applicator. As the size of the sales area or sales density increased, the effect on average total costs of increasing the size of the equipment complement decreased.

The potential to expand custom application through increasing the size of the sales area or capturing a higher market share (sales density) within a sales area are limited in western North Dakota. Generally, a single applicator could cover a sales area of 50 miles in

radius and a sales density of .5 tons/sq. mile in about 23 14-hour days. Sales areas with a radius smaller than 35 miles could be covered by a single applicator in less than 10 days. Since acres that are custom applied are so limited, a single firm with a large sales area could service most of the custom application needs within its area while competing firms provide only sales of product.

A firm in an area where the density of sales is 3 tons/sq. mile could spread all acres within a 20-mile radius or smaller in less than 27 14-hour days with one applicator. Moving to higher sales density areas similar to eastern North Dakota counties, maximum acres spread for sales areas with 7 tons/sq. mile with application rates of 200 lbs./a are higher than for sales areas with 10 tons/sq. mile and 400 lbs./a application rates. The effect of higher application rates more than offsets the increase in sales density. In these high density areas, a firm with a single applicator can service 100% of the market within a sales area of 12 miles in radius or less in less than 30 14-hour days. However, a firm with 6 applicators could not service a sales area with a 40-mile radius in less than 55 days.

As the time required for timely application of product is reduced, the size of sales area that can be serviced is reduced. Thus, western counties are ruled by low sales densities and low custom application levels that limit firms with custom application to those with the largest sales areas or old technology equipment used to cover minimal acreages. Eastern counties, high sales density, relative importance of and demand for timely custom application limit the size of the sales area and foster competition.

A constant field size was assumed for the computer simulation model to estimate acres applied and mileage for custom applicators and tender trucks. However, the effects of varying field size on acres applied/day and mileage for tenders and applicators should be considered, especially in areas with lower sales densities where field sizes are generally smaller. The capacity of the industry to resupply firms throughout the season affects the desirable plant size. Further study is needed on the physical constraints on the transport of dry fertilizer to local co-ops throughout the season. More refined estimates of the costs incurred with consolidation of facilities should be elicited.

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Appendix Table 1. Average, total fixed, and variable facility and equipment costs by annual sales volumes, for 5-mile radius sales area, by facility size, North Dakota, 1992.*

Annual sales	500 ton facility						800 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(tons)	----- \$ -----											
100	42,612	21,860	623	139	30	652.64	51,333	39,282	623	198	43	914.80
200	42,617	21,860	1,247	278	60	330.31	51,343	39,282	1,247	396	87	461.78
300	42,622	21,860	1,870	418	90	222.87	51,354	39,282	1,870	594	130	310.77
400	42,628	21,860	2,493	557	120	169.15	51,365	39,282	2,493	792	173	235.27
500	42,633	21,860	3,117	696	150	136.91	51,376	39,282	3,117	990	216	189.96
600	42,638	21,860	3,740	835	180	115.42	51,386	39,282	3,740	1,188	260	159.76
700	42,644	21,860	4,364	975	210	100.07	51,397	39,282	4,364	1,386	303	138.19
800	42,649	21,860	4,987	1,114	240	88.56	51,408	39,282	4,987	1,584	346	122.01
900	42,654	21,860	5,610	1,253	270	79.61	51,418	39,282	5,610	1,782	390	109.43
1,000	42,660	21,860	6,234	1,392	300	72.45	51,429	39,282	6,234	1,981	433	99.36
1,100	42,665	21,860	6,857	1,532	330	66.59	51,440	39,282	6,857	2,179	476	91.12
1,200	42,671	21,860	7,480	1,671	360	61.70	51,451	39,282	7,480	2,377	520	84.26
1,300	42,676	21,860	8,104	1,810	390	57.57	51,461	39,282	8,104	2,575	563	78.45
1,400	42,681	21,860	8,727	1,949	420	54.03	51,472	39,282	8,727	2,773	606	73.47
1,500	42,687	21,860	9,351	2,089	450	50.96	51,483	39,282	9,351	2,971	649	69.16
1,600	42,692	21,860	9,974	2,228	480	48.27	51,494	39,282	9,974	3,169	693	65.38
1,700	42,697	21,860	10,597	2,367	510	45.90	51,504	39,282	10,597	3,367	736	62.05
1,800	42,703	21,860	11,221	2,506	540	43.79	51,515	39,282	11,221	3,565	779	59.09
1,900	42,708	21,860	11,844	2,646	570	41.91	51,526	39,282	11,844	3,763	823	56.44
2,000	42,714	21,860	12,467	2,785	600	40.21	51,537	39,282	12,467	3,961	866	54.06
2,100	42,719	21,860	13,091	2,924	630	38.68	51,547	39,282	13,091	4,159	909	51.90
2,200	42,724	21,860	13,714	3,063	660	37.28	51,558	39,282	13,714	4,357	953	49.94
2,300	42,730	21,860	14,338	3,202	690	36.01	51,569	39,282	14,338	4,555	996	48.15
2,400	42,735	21,860	14,961	3,342	720	34.84	51,579	39,282	14,961	4,753	1,039	46.51
2,500	42,740	21,860	15,584	3,481	750	33.77	51,590	39,282	15,584	4,951	1,082	45.00
2,600	42,746	21,860	16,208	3,620	780	32.77	51,601	39,282	16,208	5,149	1,126	43.60
2,700	42,751	21,860	16,831	3,759	810	31.86	51,612	39,282	16,831	5,347	1,169	42.31
2,800	42,756	21,860	17,454	3,899	840	31.00	51,622	39,282	17,454	5,545	1,212	41.11
2,900	42,762	21,860	18,078	4,038	870	30.21	51,633	39,282	18,078	5,743	1,256	40.00
3,000	42,767	21,860	18,701	4,177	900	29.47	51,644	39,282	18,701	5,941	1,299	38.96
3,100	42,773	21,860	19,325	4,316	930	28.78	51,655	39,282	19,325	6,139	1,342	37.98
3,200	42,778	21,860	19,948	4,456	960	28.13	51,665	39,282	19,948	6,337	1,386	37.07
3,300	42,783	21,860	20,571	4,595	990	27.51	51,676	39,282	20,571	6,535	1,429	36.21
3,400	42,789	21,860	21,195	4,734	1,020	26.94	51,687	39,282	21,195	6,733	1,472	35.40
3,500	42,794	21,860	21,818	4,873	1,050	26.40	51,698	39,282	21,818	6,931	1,515	34.64
3,600	42,799	21,860	22,441	5,013	1,080	25.89	51,708	39,282	22,441	7,129	1,559	33.92
3,700	42,805	21,860	23,065	5,152	1,110	25.40	51,719	39,282	23,065	7,327	1,602	33.24
3,800	42,810	21,860	23,688	5,291	1,140	24.94	51,730	39,282	23,688	7,525	1,645	32.60
3,900	42,815	21,860	24,312	5,430	1,170	24.51	51,740	39,282	24,312	7,723	1,689	31.99
4,000	42,821	21,860	24,935	5,570	1,200	24.10	51,751	39,282	24,935	7,921	1,732	31.41
5,000	42,874	21,860	31,169	6,962	1,500	20.87	51,858	39,282	31,169	9,902	2,165	26.88
6,000	42,928	21,860	37,402	8,354	1,800	18.72	51,966	39,282	37,402	11,882	2,598	23.86
7,000	42,982	21,860	43,636	9,747	2,100	17.19	52,073	39,282	43,636	13,862	3,031	21.70

cont'd.

Appendix Table 1. (cont'd.)

Annual sales (tons)	1,300 ton facility						2,000 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
	(-)											(-)
100	99,147	77,151	623	180	37	1,771.39	121,664	126,847	623	182	34	2,493.50
200	99,163	77,151	1,246	360	75	889.98	121,691	126,847	1,246	363	67	1,251.07
300	99,179	77,151	1,868	541	112	596.17	121,718	126,847	1,868	544	101	836.93
400	99,195	77,151	2,491	721	150	449.27	121,745	126,847	2,491	726	135	629.86
500	99,212	77,151	3,114	901	187	361.13	121,771	126,847	3,114	907	169	505.62
600	99,228	77,151	3,737	1,081	224	302.37	121,798	126,847	3,737	1,088	202	422.79
700	99,244	77,151	4,359	1,261	262	260.40	121,825	126,847	4,359	1,270	236	363.63
800	99,260	77,151	4,982	1,441	299	228.92	121,852	126,847	4,982	1,451	270	319.25
900	99,276	77,151	5,605	1,621	337	204.43	121,879	126,847	5,605	1,632	304	284.74
1,000	99,292	77,151	6,228	1,801	374	184.85	121,906	126,847	6,228	1,813	337	257.13
1,100	99,308	77,151	6,851	1,981	412	168.82	121,932	126,847	6,851	1,995	371	234.54
1,200	99,324	77,151	7,473	2,161	449	155.47	121,959	126,847	7,473	2,176	405	215.72
1,300	99,340	77,151	8,096	2,341	486	144.17	121,986	126,847	8,096	2,357	438	199.79
1,400	99,356	77,151	8,719	2,522	524	134.48	122,013	126,847	8,719	2,539	472	186.14
1,500	99,373	77,151	9,342	2,702	561	126.09	122,040	126,847	9,342	2,720	506	174.30
1,600	99,389	77,151	9,964	2,882	599	118.74	122,067	126,847	9,964	2,901	540	163.95
1,700	99,405	77,151	10,587	3,062	636	112.26	122,093	126,847	10,587	3,083	573	154.81
1,800	99,421	77,151	11,210	3,242	673	106.50	122,120	126,847	11,210	3,264	607	146.69
1,900	99,437	77,151	11,833	3,422	711	101.34	122,147	126,847	11,833	3,445	641	139.43
2,000	99,453	77,151	12,456	3,602	748	96.71	122,174	126,847	12,456	3,627	674	132.89
2,100	99,469	77,151	13,078	3,782	786	92.51	122,201	126,847	13,078	3,808	708	126.97
2,200	99,485	77,151	13,701	3,962	823	88.69	122,228	126,847	13,701	3,989	742	121.59
2,300	99,501	77,151	14,324	4,142	860	85.21	122,254	126,847	14,324	4,171	776	116.68
2,400	99,517	77,151	14,947	4,323	898	82.01	122,281	126,847	14,947	4,352	809	112.18
2,500	99,534	77,151	15,570	4,503	935	79.08	122,308	126,847	15,570	4,533	843	108.04
2,600	99,550	77,151	16,192	4,683	973	76.36	122,335	126,847	16,192	4,715	877	104.22
2,700	99,566	77,151	16,815	4,863	1,010	73.85	122,362	126,847	16,815	4,896	911	100.68
2,800	99,582	77,151	17,438	5,043	1,048	71.52	122,388	126,847	17,438	5,077	944	97.39
2,900	99,598	77,151	18,061	5,223	1,085	69.35	122,415	126,847	18,061	5,259	978	94.33
3,000	99,614	77,151	18,683	5,403	1,122	67.32	122,442	126,847	18,683	5,440	1,012	91.47
3,100	99,630	77,151	19,306	5,583	1,160	65.43	122,469	126,847	19,306	5,621	1,045	88.80
3,200	99,646	77,151	19,929	5,763	1,197	63.65	122,496	126,847	19,929	5,802	1,079	86.30
3,300	99,662	77,151	20,552	5,943	1,235	61.98	122,523	126,847	20,552	5,984	1,113	83.95
3,400	99,678	77,151	21,175	6,123	1,272	60.41	122,549	126,847	21,175	6,165	1,147	81.73
3,500	99,695	77,151	21,797	6,304	1,309	58.93	122,576	126,847	21,797	6,346	1,180	79.64
3,600	99,711	77,151	22,420	6,484	1,347	57.53	122,603	126,847	22,420	6,528	1,214	77.67
3,700	99,727	77,151	23,043	6,664	1,384	56.21	122,630	126,847	23,043	6,709	1,248	75.80
3,800	99,743	77,151	23,666	6,844	1,422	54.95	122,657	126,847	23,666	6,890	1,281	74.04
3,900	99,759	77,151	24,288	7,024	1,459	53.76	122,684	126,847	24,288	7,072	1,315	72.36
4,000	99,775	77,151	24,911	7,204	1,496	52.63	122,710	126,847	24,911	7,253	1,349	70.77
5,000	99,936	77,151	31,139	9,005	1,871	43.82	122,979	126,847	31,139	9,066	1,686	58.34
6,000	100,097	77,151	37,367	10,806	2,245	37.94	123,247	126,847	37,367	10,879	2,023	50.06
7,000	100,258	77,151	43,595	12,607	2,619	33.75	123,515	126,847	43,595	12,693	2,361	44.14
8,000	100,419	77,151	49,822	14,408	2,993	30.60	123,784	126,847	49,822	14,506	2,698	39.71
9,000	100,580	77,151	56,050	16,209	3,367	28.15	124,052	126,847	56,050	16,319	3,035	36.26
10,000	100,741	77,151	62,278	18,010	3,741	26.19	124,320	126,847	62,278	18,132	3,372	33.50
11,000	100,902	77,151	68,506	19,811	4,115	24.59	124,589	126,847	68,506	19,945	3,710	31.24
12,000	101,063	77,151	74,734	21,612	4,489	23.25	124,857	126,847	74,734	21,759	4,047	29.35
13,000	101,224	77,151	80,961	23,412	4,863	22.12	125,125	126,847	80,961	23,572	4,384	27.76
14,000	101,385	77,151	87,189	25,213	5,238	21.16	125,394	126,847	87,189	25,385	4,721	26.40
15,000	101,546	77,151	93,417	27,014	5,612	20.32	125,662	126,847	93,417	27,198	5,059	25.21

cont'd.

Appendix Table 1. (cont'd.)

Annual sales	2,000 ton tower facility						4,000 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(tons)	(-	-	-	-	-	\$	-	-	-	-	-	-)
100	129,415	126,847	623	182	34	2,571.00	189,720	245,940	621	180	24	4,364.85
200	129,442	126,847	1,245	363	67	1,289.83	189,758	245,940	1,242	360	48	2,186.74
300	129,469	126,847	1,868	544	101	862.77	189,795	245,940	1,864	540	72	1,460.70
400	129,496	126,847	2,491	726	135	649.24	189,833	245,940	2,485	720	95	1,097.68
500	129,522	126,847	3,113	907	169	521.12	189,870	245,940	3,106	899	119	879.87
600	129,549	126,847	3,736	1,088	202	435.71	189,908	245,940	3,727	1,079	143	734.66
700	129,576	126,847	4,359	1,270	236	374.70	189,945	245,940	4,349	1,259	167	630.94
800	129,603	126,847	4,981	1,451	270	328.94	189,983	245,940	4,970	1,439	191	553.15
900	129,630	126,847	5,604	1,632	304	293.35	190,021	245,940	5,591	1,619	215	492.65
1,000	129,657	126,847	6,226	1,813	337	264.88	190,058	245,940	6,212	1,798	239	444.25
1,100	129,683	126,847	6,849	1,995	371	241.59	190,096	245,940	6,834	1,978	262	404.65
1,200	129,710	126,847	7,472	2,176	405	222.18	190,133	245,940	7,455	2,158	286	371.64
1,300	129,737	126,847	8,094	2,357	438	205.75	190,171	245,940	8,076	2,338	310	343.72
1,400	129,764	126,847	8,717	2,539	472	191.67	190,208	245,940	8,697	2,518	334	319.78
1,500	129,791	126,847	9,340	2,720	506	179.47	190,246	245,940	9,319	2,698	358	299.04
1,600	129,818	126,847	9,962	2,901	540	168.79	190,284	245,940	9,940	2,877	382	280.89
1,700	129,844	126,847	10,585	3,083	573	159.37	190,321	245,940	10,561	3,057	406	264.87
1,800	129,871	126,847	11,208	3,264	607	151.00	190,359	245,940	11,182	3,237	429	250.64
1,900	129,898	126,847	11,830	3,445	641	143.51	190,396	245,940	11,804	3,417	453	237.90
2,000	129,925	126,847	12,453	3,627	674	136.76	190,434	245,940	12,425	3,597	477	226.44
2,100	129,952	126,847	13,076	3,808	708	130.66	190,471	245,940	13,046	3,777	501	216.06
2,200	129,979	126,847	13,698	3,989	742	125.12	190,509	245,940	13,667	3,956	525	206.64
2,300	130,005	126,847	14,321	4,171	776	120.05	190,546	245,940	14,289	4,136	549	198.03
2,400	130,032	126,847	14,943	4,352	809	115.41	190,584	245,940	14,910	4,316	573	190.13
2,500	130,059	126,847	15,566	4,533	843	111.14	190,622	245,940	15,531	4,496	596	182.87
2,600	130,086	126,847	16,189	4,715	877	107.20	190,659	245,940	16,152	4,676	620	176.17
2,700	130,113	126,847	16,811	4,896	911	103.55	190,697	245,940	16,774	4,855	644	169.97
2,800	130,139	126,847	17,434	5,077	944	100.16	190,734	245,940	17,395	5,035	668	164.20
2,900	130,166	126,847	18,057	5,259	978	97.00	190,772	245,940	18,016	5,215	692	158.84
3,000	130,193	126,847	18,679	5,440	1,012	94.06	190,809	245,940	18,637	5,395	716	153.83
3,100	130,220	126,847	19,302	5,621	1,045	91.30	190,847	245,940	19,258	5,575	740	149.15
3,200	130,247	126,847	19,925	5,802	1,079	88.72	190,885	245,940	19,880	5,755	763	144.76
3,300	130,274	126,847	20,547	5,984	1,113	86.29	190,922	245,940	20,501	5,934	787	140.63
3,400	130,300	126,847	21,170	6,165	1,147	84.01	190,960	245,940	21,122	6,114	811	136.75
3,500	130,327	126,847	21,793	6,346	1,180	81.86	190,997	245,940	21,743	6,294	835	133.09
3,600	130,354	126,847	22,415	6,528	1,214	79.82	191,035	245,940	22,365	6,474	859	129.63
3,700	130,381	126,847	23,038	6,709	1,248	77.90	191,072	245,940	22,986	6,654	883	126.36
3,800	130,408	126,847	23,661	6,890	1,281	76.08	191,110	245,940	23,607	6,834	907	123.26
3,900	130,435	126,847	24,283	7,072	1,315	74.35	191,147	245,940	24,228	7,013	930	120.32
4,000	130,461	126,847	24,906	7,253	1,349	72.70	191,185	245,940	24,850	7,193	954	117.53
5,000	130,730	126,847	31,132	9,066	1,686	59.89	191,561	245,940	31,062	8,991	1,193	95.75
6,000	130,998	126,847	37,359	10,879	2,023	51.35	191,936	245,940	37,274	10,790	1,431	81.23
7,000	131,266	126,847	43,585	12,693	2,361	45.25	192,312	245,940	43,487	12,588	1,670	70.86
8,000	131,535	126,847	49,812	14,506	2,698	40.67	192,688	245,940	49,699	14,386	1,909	63.08
9,000	131,803	126,847	56,038	16,319	3,035	37.12	193,063	245,940	55,912	16,184	2,147	57.03
10,000	132,071	126,847	62,265	18,132	3,372	34.27	193,439	245,940	62,124	17,983	2,386	52.19
11,000	132,340	126,847	68,491	19,945	3,710	31.94	193,814	245,940	68,337	19,781	2,624	48.23
12,000	132,608	126,847	74,717	21,759	4,047	30.00	194,190	245,940	74,549	21,579	2,863	44.93
13,000	132,876	126,847	80,944	23,572	4,384	28.36	194,566	245,940	80,761	23,377	3,102	42.13
14,000	133,145	126,847	87,170	25,385	4,721	26.95	194,941	245,940	86,974	25,175	3,340	39.74
15,000	133,413	126,847	93,397	27,198	5,059	25.73	195,317	245,940	93,186	26,974	3,579	37.67

* Costs not reported when sales exceed equipment capacity.

** Changes in fixed costs reflect assumed positive relationship between facility land values and sales density.

Appendix Table 2. Fixed and variable costs related to volume and radius of sales area for specified sizes of dry fertilizer custom application facilities for a 12.5 mile radius sales area, North Dakota, 1992.*

Annual sales (tons)	500 ton facility						800 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
	----- \$ -----											
100	42,607	21,860	623	138	72	653.00	51,324	39,282	623	192	120	915.42
200	42,608	21,860	1,247	275	144	330.67	51,325	39,282	1,247	384	241	462.40
300	42,609	21,860	1,870	413	216	223.23	51,327	39,282	1,870	576	361	311.39
400	42,610	21,860	2,493	550	288	169.50	51,329	39,282	2,493	768	481	235.89
500	42,610	21,860	3,117	688	359	137.27	51,330	39,282	3,117	960	602	190.58
600	42,611	21,860	3,740	826	431	115.78	51,332	39,282	3,740	1,152	722	160.38
700	42,612	21,860	4,364	963	503	100.43	51,334	39,282	4,364	1,344	842	138.81
800	42,613	21,860	4,987	1,101	575	88.92	51,336	39,282	4,987	1,536	963	122.63
900	42,614	21,860	5,610	1,239	647	79.97	51,337	39,282	5,610	1,728	1,083	110.05
1,000	42,615	21,860	6,234	1,376	719	72.80	51,339	39,282	6,234	1,920	1,203	99.98
1,100	42,616	21,860	6,857	1,514	791	66.94	51,341	39,282	6,857	2,112	1,324	91.74
1,200	42,616	21,860	7,480	1,651	863	62.06	51,342	39,282	7,480	2,304	1,444	84.88
1,300	42,617	21,860	8,104	1,789	935	57.93	51,344	39,282	8,104	2,496	1,564	79.07
1,400	42,618	21,860	8,727	1,927	1,007	54.38	51,346	39,282	8,727	2,688	1,685	74.09
1,500	42,619	21,860	9,351	2,064	1,078	51.32	51,348	39,282	9,351	2,880	1,805	69.78
1,600	42,620	21,860	9,974	2,202	1,150	48.63	51,349	39,282	9,974	3,072	1,925	66.00
1,700	42,621	21,860	10,597	2,340	1,222	46.26	51,351	39,282	10,597	3,264	2,046	62.67
1,800	42,622	21,860	11,221	2,477	1,294	44.15	51,353	39,282	11,221	3,456	2,166	59.71
1,900	42,622	21,860	11,844	2,615	1,366	42.27	51,355	39,282	11,844	3,648	2,286	57.06
2,000	42,623	21,860	12,467	2,752	1,438	40.57	51,356	39,282	12,467	3,840	2,407	54.68
2,100	42,624	21,860	13,091	2,890	1,510	39.04	51,358	39,282	13,091	4,032	2,527	52.52
2,200	42,625	21,860	13,714	3,028	1,582	37.64	51,360	39,282	13,714	4,224	2,647	50.56
2,300	42,626	21,860	14,338	3,165	1,654	36.37	51,361	39,282	14,338	4,416	2,768	48.77
2,400	42,627	21,860	14,961	3,303	1,725	35.20	51,363	39,282	14,961	4,608	2,888	47.13
2,500	42,628	21,860	15,584	3,441	1,797	34.12	51,365	39,282	15,584	4,800	3,008	45.62
2,600	42,629	21,860	16,208	3,578	1,869	33.13	51,367	39,282	16,208	4,992	3,129	44.22
2,700	42,629	21,860	16,831	3,716	1,941	32.21	51,368	39,282	16,831	5,185	3,249	42.93
2,800	42,630	21,860	17,454	3,853	2,013	31.36	51,370	39,282	17,454	5,377	3,369	41.73
2,900	42,631	21,860	18,078	3,991	2,085	30.57	51,372	39,282	18,078	5,569	3,490	40.62
3,000	42,632	21,860	18,701	4,129	2,157	29.83	51,373	39,282	18,701	5,761	3,610	39.58
3,100	42,633	21,860	19,325	4,266	2,229	29.13	51,375	39,282	19,325	5,953	3,730	38.60
3,200	42,634	21,860	19,948	4,404	2,301	28.48	51,377	39,282	19,948	6,145	3,851	37.69
3,300	42,635	21,860	20,571	4,542	2,372	27.87	51,379	39,282	20,571	6,337	3,971	36.83
3,400	42,635	21,860	21,195	4,679	2,444	27.30	51,380	39,282	21,195	6,529	4,091	36.02
3,500	42,636	21,860	21,818	4,817	2,516	26.76	51,382	39,282	21,818	6,721	4,212	35.26
3,600	42,637	21,860	22,441	4,954	2,588	26.24	51,384	39,282	22,441	6,913	4,332	34.54
3,700	42,638	21,860	23,065	5,092	2,660	25.76	51,385	39,282	23,065	7,105	4,452	33.86
3,800	42,639	21,860	23,688	5,230	2,732	25.30	51,387	39,282	23,688	7,297	4,573	33.22
3,900	42,640	21,860	24,312	5,367	2,804	24.87	51,389	39,282	24,312	7,489	4,693	32.61
4,000	42,641	21,860	24,935	5,505	2,876	24.45	51,391	39,282	24,935	7,681	4,813	32.03
5,000	42,649	21,860	31,169	6,881	3,595	21.23	51,408	39,282	31,169	9,601	6,017	27.50
6,000	42,658	21,860	37,402	8,257	4,314	19.08	51,425	39,282	37,402	11,521	7,220	24.48
7,000	42,666	21,860	43,636	9,634	5,033	17.55	51,442	39,282	43,636	13,441	8,424	22.32

cont'd.

Appendix Table 2. (cont'd.)

Annual sales	1,300 ton facility						2,000 ton facility					
	Fixed costs		Variable costs related to:			Total/ton	Fixed costs		Variable costs related to:			Total/ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(tons)	(-)	(-)	(-)	(-)	(-)	\$	(-)	(-)	(-)	(-)	(-)	(-)
100	99,134	77,151	623	175	106	1,771.89	121,642	126,847	623	177	97	2,493.86
200	99,136	77,151	1,246	350	213	890.48	121,646	126,847	1,246	353	194	1,251.43
300	99,139	77,151	1,868	525	319	596.67	121,650	126,847	1,868	530	291	837.29
400	99,141	77,151	2,491	699	425	449.77	121,654	126,847	2,491	706	389	630.22
500	99,144	77,151	3,114	874	531	361.63	121,659	126,847	3,114	883	486	505.98
600	99,147	77,151	3,737	1,049	638	302.87	121,663	126,847	3,737	1,059	583	423.15
700	99,149	77,151	4,359	1,224	744	260.90	121,667	126,847	4,359	1,236	680	363.99
800	99,152	77,151	4,982	1,399	850	229.42	121,672	126,847	4,982	1,412	777	319.61
900	99,154	77,151	5,605	1,573	956	204.93	121,676	126,847	5,605	1,588	874	285.10
1,000	99,157	77,151	6,228	1,748	1,063	185.35	121,680	126,847	6,228	1,765	971	257.49
1,100	99,159	77,151	6,851	1,923	1,169	169.32	121,684	126,847	6,851	1,941	1,069	234.90
1,200	99,162	77,151	7,473	2,098	1,275	155.97	121,689	126,847	7,473	2,118	1,166	216.08
1,300	99,165	77,151	8,096	2,273	1,382	144.67	121,693	126,847	8,096	2,294	1,263	200.15
1,400	99,167	77,151	8,719	2,447	1,488	134.98	121,697	126,847	8,719	2,471	1,360	186.50
1,500	99,170	77,151	9,342	2,622	1,594	126.59	121,702	126,847	9,342	2,647	1,457	174.66
1,600	99,172	77,151	9,964	2,797	1,700	119.24	121,706	126,847	9,964	2,824	1,554	164.31
1,700	99,175	77,151	10,587	2,972	1,807	112.76	121,710	126,847	10,587	3,000	1,651	155.17
1,800	99,177	77,151	11,210	3,147	1,913	107.00	121,715	126,847	11,210	3,177	1,748	147.05
1,900	99,180	77,151	11,833	3,321	2,019	101.84	121,719	126,847	11,833	3,353	1,846	139.79
2,000	99,183	77,151	12,456	3,496	2,126	97.21	121,723	126,847	12,456	3,530	1,943	133.25
2,100	99,185	77,151	13,078	3,671	2,232	93.01	121,727	126,847	13,078	3,706	2,040	127.33
2,200	99,188	77,151	13,701	3,846	2,338	89.19	121,732	126,847	13,701	3,883	2,137	121.95
2,300	99,190	77,151	14,324	4,021	2,444	85.71	121,736	126,847	14,324	4,059	2,234	117.04
2,400	99,193	77,151	14,947	4,195	2,551	82.52	121,740	126,847	14,947	4,236	2,331	112.54
2,500	99,195	77,151	15,570	4,370	2,657	79.58	121,745	126,847	15,570	4,412	2,428	108.40
2,600	99,198	77,151	16,192	4,545	2,763	76.87	121,749	126,847	16,192	4,589	2,526	104.58
2,700	99,201	77,151	16,815	4,720	2,869	74.35	121,753	126,847	16,815	4,765	2,623	101.04
2,800	99,203	77,151	17,438	4,895	2,976	72.02	121,757	126,847	17,438	4,941	2,720	97.75
2,900	99,206	77,151	18,061	5,069	3,082	69.85	121,762	126,847	18,061	5,118	2,817	94.69
3,000	99,208	77,151	18,683	5,244	3,188	67.83	121,766	126,847	18,683	5,294	2,914	91.84
3,100	99,211	77,151	19,306	5,419	3,295	65.93	121,770	126,847	19,306	5,471	3,011	89.16
3,200	99,214	77,151	19,929	5,594	3,401	64.15	121,775	126,847	19,929	5,647	3,108	86.66
3,300	99,216	77,151	20,552	5,768	3,507	62.48	121,779	126,847	20,552	5,824	3,206	84.31
3,400	99,219	77,151	21,175	5,943	3,613	60.91	121,783	126,847	21,175	6,000	3,303	82.09
3,500	99,221	77,151	21,797	6,118	3,720	59.43	121,787	126,847	21,797	6,177	3,400	80.00
3,600	99,224	77,151	22,420	6,293	3,826	58.03	121,792	126,847	22,420	6,353	3,497	78.03
3,700	99,226	77,151	23,043	6,468	3,932	56.71	121,796	126,847	23,043	6,530	3,594	76.16
3,800	99,229	77,151	23,666	6,642	4,038	55.45	121,800	126,847	23,666	6,706	3,691	74.40
3,900	99,232	77,151	24,288	6,817	4,145	54.26	121,805	126,847	24,288	6,883	3,788	72.72
4,000	99,234	77,151	24,911	6,992	4,251	53.13	121,809	126,847	24,911	7,059	3,886	71.13
5,000	99,260	77,151	31,139	8,740	5,314	44.32	121,852	126,847	31,139	8,824	4,857	58.70
6,000	99,286	77,151	37,367	10,488	6,377	38.44	121,895	126,847	37,367	10,589	5,828	50.42
7,000	99,311	77,151	43,595	12,236	7,439	34.25	121,938	126,847	43,595	12,353	6,800	44.50
8,000	99,337	77,151	49,822	13,984	8,502	31.10	121,981	126,847	49,822	14,118	7,771	40.07
9,000	99,363	77,151	56,050	15,732	9,565	28.65	122,024	126,847	56,050	15,883	8,742	36.62
10,000	99,389	77,151	62,278	17,480	10,628	26.69	122,067	126,847	62,278	17,647	9,714	33.86
11,000	99,414	77,151	68,506	19,228	11,690	25.09	122,109	126,847	68,506	19,412	10,685	31.60
12,000	99,440	77,151	74,734	20,976	12,753	23.75	122,152	126,847	74,734	21,177	11,657	29.71
13,000	99,466	77,151	80,961	22,724	13,816	22.62	122,195	126,847	80,961	22,942	12,628	28.12
14,000	99,492	77,151	87,189	24,472	14,879	21.66	122,238	126,847	87,189	24,706	13,599	26.76
15,000	99,517	77,151	93,417	26,220	15,941	20.82	122,281	126,847	93,417	26,471	14,571	25.57

cont'd.

Appendix Table 2. (cont'd.)

Annual sales	2,000 ton tower facility						4,000 ton facility					
	Fixed costs		Variable costs related to:			Total/ton	Fixed costs		Variable costs related to:			Total/ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(tons)	(-----)	(-----)	(-----)	(-----)	(-----)	\$	(-----)	(-----)	(-----)	(-----)	(-----)	(-----)
100	129,393	126,847	623	177	97	2,571.36	189,689	245,940	621	179	74	4,365.02
200	129,397	126,847	1,245	353	194	1,290.19	189,695	245,940	1,242	357	147	2,186.91
300	129,401	126,847	1,868	530	291	863.13	189,701	245,940	1,864	536	221	1,460.87
400	129,405	126,847	2,491	706	389	649.60	189,707	245,940	2,485	714	295	1,097.85
500	129,410	126,847	3,113	883	486	521.48	189,713	245,940	3,106	893	369	880.04
600	129,414	126,847	3,736	1,059	583	436.07	189,719	245,940	3,727	1,071	442	734.83
700	129,418	126,847	4,359	1,236	680	375.06	189,725	245,940	4,349	1,250	516	631.11
800	129,423	126,847	4,981	1,412	777	329.30	189,731	245,940	4,970	1,428	590	553.32
900	129,427	126,847	5,604	1,588	874	293.71	189,737	245,940	5,591	1,607	664	492.82
1,000	129,431	126,847	6,226	1,765	971	265.24	189,743	245,940	6,212	1,785	737	444.42
1,100	129,435	126,847	6,849	1,941	1,069	241.95	189,749	245,940	6,834	1,964	811	404.82
1,200	129,440	126,847	7,472	2,118	1,166	222.54	189,755	245,940	7,455	2,142	885	371.81
1,300	129,444	126,847	8,094	2,294	1,263	206.11	189,761	245,940	8,076	2,320	959	343.89
1,400	129,448	126,847	8,717	2,471	1,360	192.03	189,767	245,940	8,697	2,499	1,032	319.95
1,500	129,453	126,847	9,340	2,647	1,457	179.83	189,773	245,940	9,319	2,677	1,106	299.21
1,600	129,457	126,847	9,962	2,824	1,554	169.15	189,779	245,940	9,940	2,856	1,180	281.06
1,700	129,461	126,847	10,585	3,000	1,651	159.73	189,785	245,940	10,561	3,034	1,254	265.04
1,800	129,466	126,847	11,208	3,177	1,748	151.36	189,791	245,940	11,182	3,213	1,327	250.81
1,900	129,470	126,847	11,830	3,353	1,846	143.87	189,797	245,940	11,804	3,391	1,401	238.07
2,000	129,474	126,847	12,453	3,530	1,943	137.12	189,803	245,940	12,425	3,570	1,475	226.61
2,100	129,478	126,847	13,076	3,706	2,040	131.02	189,809	245,940	13,046	3,748	1,548	216.23
2,200	129,483	126,847	13,698	3,883	2,137	125.48	189,815	245,940	13,667	3,927	1,622	206.81
2,300	129,487	126,847	14,321	4,059	2,234	120.41	189,821	245,940	14,289	4,105	1,696	198.20
2,400	129,491	126,847	14,943	4,236	2,331	115.77	189,827	245,940	14,910	4,284	1,770	190.30
2,500	129,496	126,847	15,566	4,412	2,428	111.50	189,833	245,940	15,531	4,462	1,843	183.04
2,600	129,500	126,847	16,189	4,589	2,526	107.56	189,839	245,940	16,152	4,641	1,917	176.34
2,700	129,504	126,847	16,811	4,765	2,623	103.91	189,845	245,940	16,774	4,819	1,991	170.14
2,800	129,508	126,847	17,434	4,941	2,720	100.52	189,851	245,940	17,395	4,998	2,065	164.37
2,900	129,513	126,847	18,057	5,118	2,817	97.36	189,857	245,940	18,016	5,176	2,138	159.01
3,000	129,517	126,847	18,679	5,294	2,914	94.42	189,863	245,940	18,637	5,355	2,212	154.00
3,100	129,521	126,847	19,302	5,471	3,011	91.66	189,869	245,940	19,258	5,533	2,286	149.32
3,200	129,526	126,847	19,925	5,647	3,108	89.08	189,875	245,940	19,880	5,712	2,360	144.93
3,300	129,530	126,847	20,547	5,824	3,206	86.65	189,881	245,940	20,501	5,890	2,433	140.80
3,400	129,534	126,847	21,170	6,000	3,303	84.37	189,887	245,940	21,122	6,069	2,507	136.92
3,500	129,538	126,847	21,793	6,177	3,400	82.22	189,893	245,940	21,743	6,247	2,581	133.26
3,600	129,543	126,847	22,415	6,353	3,497	80.18	189,899	245,940	22,365	6,425	2,655	129.80
3,700	129,547	126,847	23,038	6,530	3,594	78.26	189,905	245,940	22,986	6,604	2,728	126.53
3,800	129,551	126,847	23,661	6,706	3,691	76.44	189,911	245,940	23,607	6,782	2,802	123.43
3,900	129,556	126,847	24,283	6,883	3,788	74.71	189,917	245,940	24,228	6,961	2,876	120.49
4,000	129,560	126,847	24,906	7,059	3,886	73.06	189,923	245,940	24,850	7,139	2,950	117.70
5,000	129,603	126,847	31,132	8,824	4,857	60.25	189,983	245,940	31,062	8,924	3,687	95.92
6,000	129,646	126,847	37,359	10,589	5,828	51.71	190,043	245,940	37,274	10,709	4,424	81.40
7,000	129,689	126,847	43,585	12,353	6,800	45.61	190,103	245,940	43,487	12,494	5,162	71.03
8,000	129,732	126,847	49,812	14,118	7,771	41.03	190,163	245,940	49,699	14,279	5,899	63.25
9,000	129,775	126,847	56,038	15,883	8,742	37.48	190,223	245,940	55,912	16,063	6,636	57.20
10,000	129,818	126,847	62,265	17,647	9,714	34.63	190,284	245,940	62,124	17,848	7,374	52.36
11,000	129,860	126,847	68,491	19,412	10,685	32.30	190,344	245,940	68,337	19,633	8,111	48.40
12,000	129,903	126,847	74,717	21,177	11,657	30.36	190,404	245,940	74,549	21,418	8,849	45.10
13,000	129,946	126,847	80,944	22,942	12,628	28.72	190,464	245,940	80,761	23,202	9,586	42.30
14,000	129,989	126,847	87,170	24,706	13,599	27.31	190,524	245,940	86,974	24,987	10,323	39.91
15,000	130,032	126,847	93,397	26,471	14,571	26.09	190,584	245,940	93,186	26,772	11,061	37.84

* Costs not reported when sales exceed equipment capacity.

** Changes in fixed costs reflect assumed positive relationship between facility land values and sales density.

Appendix Table 3. Fixed and variable costs related to volume and radius of sales area for specified sizes of dry fertilizer custom application facilities for a 20 mile radius sales area, North Dakota, 1992.*

Annual sales	500 ton facility						800 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(tons)	(-	-	-	-	-	\$	-	-	-	-	-	-)
100	42,607	21,860	623	138	114	653.41	51,323	39,282	623	189	197	916.15
200	42,607	21,860	1,247	275	228	331.08	51,323	39,282	1,247	378	395	463.12
300	42,607	21,860	1,870	413	341	223.64	51,324	39,282	1,870	566	592	312.12
400	42,608	21,860	2,493	550	455	169.92	51,325	39,282	2,493	755	790	236.61
500	42,608	21,860	3,117	688	569	137.68	51,325	39,282	3,117	944	987	191.31
600	42,608	21,860	3,740	826	683	116.19	51,326	39,282	3,740	1,133	1,184	161.11
700	42,609	21,860	4,364	963	797	100.85	51,327	39,282	4,364	1,322	1,382	139.54
800	42,609	21,860	4,987	1,101	910	89.33	51,327	39,282	4,987	1,510	1,579	123.36
900	42,609	21,860	5,610	1,238	1,024	80.38	51,328	39,282	5,610	1,699	1,776	110.77
1,000	42,610	21,860	6,234	1,376	1,138	73.22	51,329	39,282	6,234	1,888	1,974	100.71
1,100	42,610	21,860	6,857	1,514	1,252	67.36	51,329	39,282	6,857	2,077	2,171	92.47
1,200	42,610	21,860	7,480	1,651	1,366	62.47	51,330	39,282	7,480	2,265	2,369	85.61
1,300	42,611	21,860	8,104	1,789	1,479	58.34	51,331	39,282	8,104	2,454	2,566	79.80
1,400	42,611	21,860	8,727	1,926	1,593	54.80	51,331	39,282	8,727	2,643	2,763	74.82
1,500	42,611	21,860	9,351	2,064	1,707	51.73	51,332	39,282	9,351	2,832	2,961	70.50
1,600	42,612	21,860	9,974	2,201	1,821	49.04	51,333	39,282	9,974	3,020	3,158	66.73
1,700	42,612	21,860	10,597	2,339	1,934	46.67	51,333	39,282	10,597	3,209	3,355	63.40
1,800	42,612	21,860	11,221	2,477	2,048	44.57	51,334	39,282	11,221	3,398	3,553	60.44
1,900	42,613	21,860	11,844	2,614	2,162	42.68	51,335	39,282	11,844	3,587	3,750	57.79
2,000	42,613	21,860	12,467	2,752	2,276	40.98	51,335	39,282	12,467	3,775	3,948	55.40
2,100	42,613	21,860	13,091	2,889	2,390	39.45	51,336	39,282	13,091	3,964	4,145	53.25
2,200	42,614	21,860	13,714	3,027	2,503	38.05	51,337	39,282	13,714	4,153	4,342	51.29
2,300	42,614	21,860	14,338	3,165	2,617	36.78	51,337	39,282	14,338	4,342	4,540	49.49
2,400	42,614	21,860	14,961	3,302	2,731	35.61	51,338	39,282	14,961	4,530	4,737	47.85
2,500	42,615	21,860	15,584	3,440	2,845	34.54	51,339	39,282	15,584	4,719	4,934	46.34
2,600	42,615	21,860	16,208	3,577	2,959	33.55	51,339	39,282	16,208	4,908	5,132	44.95
2,700	42,615	21,860	16,831	3,715	3,072	32.63	51,340	39,282	16,831	5,097	5,329	43.66
2,800	42,616	21,860	17,454	3,853	3,186	31.77	51,341	39,282	17,454	5,285	5,527	42.46
2,900	42,616	21,860	18,078	3,990	3,300	30.98	51,341	39,282	18,078	5,474	5,724	41.34
3,000	42,616	21,860	18,701	4,128	3,414	30.24	51,342	39,282	18,701	5,663	5,921	40.30
3,100	42,617	21,860	19,325	4,265	3,528	29.55	51,343	39,282	19,325	5,852	6,119	39.33
3,200	42,617	21,860	19,948	4,403	3,641	28.90	51,343	39,282	19,948	6,040	6,316	38.42
3,300	42,617	21,860	20,571	4,541	3,755	28.29	51,344	39,282	20,571	6,229	6,513	37.56
3,400	42,618	21,860	21,195	4,678	3,869	27.71	51,345	39,282	21,195	6,418	6,711	36.75
3,500	42,618	21,860	21,818	4,816	3,983	27.17	51,345	39,282	21,818	6,607	6,908	35.99
3,600	42,618	21,860	22,441	4,953	4,097	26.66	51,346	39,282	22,441	6,796	7,106	35.27
3,700	42,619	21,860	23,065	5,091	4,210	26.17	51,347	39,282	23,065	6,984	7,303	34.59
3,800	42,619	21,860	23,688	5,229	4,324	25.72	51,347	39,282	23,688	7,173	7,500	33.95
3,900	42,619	21,860	24,312	5,366	4,438	25.28	51,348	39,282	24,312	7,362	7,698	33.33
4,000	42,620	21,860	24,935	5,504	4,552	24.87	51,349	39,282	24,935	7,551	7,895	32.75
5,000	42,623	21,860	31,169	6,880	5,690	21.64	51,355	39,282	31,169	9,438	9,869	28.22
6,000	42,626	21,860	37,402	8,256	6,828	19.50	51,362	39,282	37,402	11,326	11,843	25.20

cont'd.

Appendix Table 3. (cont'd.)

Annual sales (tons)	1,300 ton facility						2,000 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(- - - - -)	(- - - - -)	(- - - - -)	(- - - - -)	(- - - - -)	(- - - - -)	\$	(- - - - -)	(- - - - -)	(- - - - -)	(- - - - -)	(- - - - -)	(- - - - -)
100	99,132	77,151	623	172	175	1,772.54	121,639	126,847	623	175	161	2,494.45
200	99,133	77,151	1,246	344	350	891.12	121,641	126,847	1,246	351	321	1,252.03
300	99,134	77,151	1,868	517	525	597.32	121,642	126,847	1,868	526	482	837.89
400	99,135	77,151	2,491	689	701	450.42	121,644	126,847	2,491	701	642	630.81
500	99,136	77,151	3,114	861	876	362.28	121,646	126,847	3,114	876	803	506.57
600	99,137	77,151	3,737	1,033	1,051	303.51	121,647	126,847	3,737	1,051	963	423.74
700	99,138	77,151	4,359	1,205	1,226	261.54	121,649	126,847	4,359	1,227	1,124	364.58
800	99,139	77,151	4,982	1,377	1,401	230.06	121,651	126,847	4,982	1,402	1,284	320.21
900	99,140	77,151	5,605	1,549	1,576	205.58	121,652	126,847	5,605	1,577	1,445	285.70
1,000	99,141	77,151	6,228	1,721	1,751	185.99	121,654	126,847	6,228	1,752	1,606	258.09
1,100	99,142	77,151	6,851	1,894	1,927	169.97	121,656	126,847	6,851	1,928	1,766	235.50
1,200	99,143	77,151	7,473	2,066	2,102	156.61	121,657	126,847	7,473	2,103	1,927	216.67
1,300	99,144	77,151	8,096	2,238	2,277	145.31	121,659	126,847	8,096	2,278	2,087	200.74
1,400	99,145	77,151	8,719	2,410	2,452	135.63	121,661	126,847	8,719	2,453	2,248	187.09
1,500	99,146	77,151	9,342	2,582	2,627	127.23	121,662	126,847	9,342	2,628	2,408	175.26
1,600	99,147	77,151	9,964	2,754	2,802	119.89	121,664	126,847	9,964	2,804	2,569	164.91
1,700	99,148	77,151	10,587	2,926	2,977	113.41	121,666	126,847	10,587	2,979	2,729	155.77
1,800	99,149	77,151	11,210	3,098	3,153	107.65	121,667	126,847	11,210	3,154	2,890	147.65
1,900	99,150	77,151	11,833	3,271	3,328	102.49	121,669	126,847	11,833	3,329	3,050	140.38
2,000	99,151	77,151	12,456	3,443	3,503	97.85	121,671	126,847	12,456	3,504	3,211	133.84
2,100	99,152	77,151	13,078	3,615	3,678	93.65	121,672	126,847	13,078	3,680	3,372	127.93
2,200	99,153	77,151	13,701	3,787	3,853	89.84	121,674	126,847	13,701	3,855	3,532	122.55
2,300	99,154	77,151	14,324	3,959	4,028	86.36	121,676	126,847	14,324	4,030	3,693	117.64
2,400	99,155	77,151	14,947	4,131	4,203	83.16	121,677	126,847	14,947	4,205	3,853	113.14
2,500	99,156	77,151	15,570	4,303	4,379	80.22	121,679	126,847	15,570	4,380	4,014	109.00
2,600	99,157	77,151	16,192	4,475	4,554	77.51	121,681	126,847	16,192	4,556	4,174	105.17
2,700	99,158	77,151	16,815	4,648	4,729	75.00	121,683	126,847	16,815	4,731	4,335	101.63
2,800	99,159	77,151	17,438	4,820	4,904	72.67	121,684	126,847	17,438	4,906	4,495	98.35
2,900	99,160	77,151	18,061	4,992	5,079	70.50	121,686	126,847	18,061	5,081	4,656	95.29
3,000	99,161	77,151	18,683	5,164	5,254	68.47	121,688	126,847	18,683	5,256	4,817	92.43
3,100	99,162	77,151	19,306	5,336	5,429	66.58	121,689	126,847	19,306	5,432	4,977	89.76
3,200	99,163	77,151	19,929	5,508	5,604	64.80	121,691	126,847	19,929	5,607	5,138	87.25
3,300	99,164	77,151	20,552	5,680	5,780	63.13	121,693	126,847	20,552	5,782	5,298	84.90
3,400	99,165	77,151	21,175	5,852	5,955	61.56	121,694	126,847	21,175	5,957	5,459	82.69
3,500	99,166	77,151	21,797	6,024	6,130	60.08	121,696	126,847	21,797	6,133	5,619	80.60
3,600	99,167	77,151	22,420	6,197	6,305	58.68	121,698	126,847	22,420	6,308	5,780	78.63
3,700	99,168	77,151	23,043	6,369	6,480	57.35	121,699	126,847	23,043	6,483	5,940	76.76
3,800	99,169	77,151	23,666	6,541	6,655	56.10	121,701	126,847	23,666	6,658	6,101	74.99
3,900	99,170	77,151	24,288	6,713	6,830	54.91	121,703	126,847	24,288	6,833	6,262	73.32
4,000	99,171	77,151	24,911	6,885	7,006	53.78	121,704	126,847	24,911	7,009	6,422	71.72
5,000	99,181	77,151	31,139	8,606	8,757	44.97	121,721	126,847	31,139	8,761	8,028	59.30
6,000	99,191	77,151	37,367	10,328	10,508	39.09	121,738	126,847	37,367	10,513	9,633	51.02
7,000	99,202	77,151	43,595	12,049	12,260	34.89	121,755	126,847	43,595	12,265	11,239	45.10
8,000	99,212	77,151	49,822	13,770	14,011	31.75	121,771	126,847	49,822	14,017	12,844	40.66
9,000	99,222	77,151	56,050	15,491	15,763	29.30	121,788	126,847	56,050	15,769	14,450	37.21
10,000	99,232	77,151	62,278	17,212	17,514	27.34	121,805	126,847	62,278	17,521	16,055	34.45
11,000	99,242	77,151	68,506	18,934	19,265	25.74	121,822	126,847	68,506	19,273	17,661	32.19
12,000	99,252	77,151	74,734	20,655	21,017	24.40	121,838	126,847	74,734	21,025	19,266	30.31
13,000	99,262	77,151	80,961	22,376	22,768	23.27	121,855	126,847	80,961	22,777	20,872	28.72
14,000	99,272	77,151	87,189	24,097	24,520	22.30	121,872	126,847	87,189	24,529	22,477	27.35
15,000							121,889	126,847	93,417	26,281	24,083	26.17

cont'd.

Appendix Table 3. (cont'd.)

Annual sales	2,000 ton tower facility						4,000 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(tons)	(-	-	-	-	-	\$	-	-	-	-	-	-)
100	129,390	126,847	623	175	161	2,571.96	189,685	245,940	621	179	124	4,365.49
200	129,392	126,847	1,245	351	321	1,290.78	189,687	245,940	1,242	358	247	2,187.37
300	129,393	126,847	1,868	526	482	863.72	189,690	245,940	1,864	537	371	1,461.34
400	129,395	126,847	2,491	701	642	650.19	189,692	245,940	2,485	716	494	1,098.32
500	129,397	126,847	3,113	876	803	522.07	189,694	245,940	3,106	894	618	880.51
600	129,398	126,847	3,736	1,051	963	436.66	189,697	245,940	3,727	1,073	742	735.30
700	129,400	126,847	4,359	1,227	1,124	375.65	189,699	245,940	4,349	1,252	865	631.58
800	129,402	126,847	4,981	1,402	1,284	329.90	189,701	245,940	4,970	1,431	989	553.79
900	129,403	126,847	5,604	1,577	1,445	294.31	189,704	245,940	5,591	1,610	1,113	493.29
1,000	129,405	126,847	6,226	1,752	1,606	265.84	189,706	245,940	6,212	1,788	1,236	444.88
1,100	129,407	126,847	6,849	1,928	1,766	242.54	189,708	245,940	6,834	1,967	1,360	405.28
1,200	129,408	126,847	7,472	2,103	1,927	223.13	189,711	245,940	7,455	2,146	1,483	372.28
1,300	129,410	126,847	8,094	2,278	2,087	206.71	189,713	245,940	8,076	2,325	1,607	344.35
1,400	129,412	126,847	8,717	2,453	2,248	192.63	189,715	245,940	8,697	2,504	1,731	320.42
1,500	129,413	126,847	9,340	2,628	2,408	180.42	189,718	245,940	9,319	2,683	1,854	299.68
1,600	129,415	126,847	9,962	2,804	2,569	169.75	189,720	245,940	9,940	2,861	1,978	281.52
1,700	129,417	126,847	10,585	2,979	2,729	160.33	189,722	245,940	10,561	3,040	2,102	265.51
1,800	129,418	126,847	11,208	3,154	2,890	151.95	189,725	245,940	11,182	3,219	2,225	251.27
1,900	129,420	126,847	11,830	3,329	3,050	144.46	189,727	245,940	11,804	3,398	2,349	238.54
2,000	129,422	126,847	12,453	3,504	3,211	137.72	189,730	245,940	12,425	3,577	2,472	227.07
2,100	129,423	126,847	13,076	3,680	3,372	131.62	189,732	245,940	13,046	3,756	2,596	216.70
2,200	129,425	126,847	13,698	3,855	3,532	126.07	189,734	245,940	13,667	3,934	2,720	207.27
2,300	129,427	126,847	14,321	4,030	3,693	121.01	189,737	245,940	14,289	4,113	2,843	198.66
2,400	129,428	126,847	14,943	4,205	3,853	116.37	189,739	245,940	14,910	4,292	2,967	190.77
2,500	129,430	126,847	15,566	4,380	4,014	112.10	189,741	245,940	15,531	4,471	3,090	183.51
2,600	129,432	126,847	16,189	4,556	4,174	108.15	189,744	245,940	16,152	4,650	3,214	176.81
2,700	129,434	126,847	16,811	4,731	4,335	104.50	189,746	245,940	16,774	4,829	3,338	170.60
2,800	129,435	126,847	17,434	4,906	4,495	101.11	189,748	245,940	17,395	5,007	3,461	164.84
2,900	129,437	126,847	18,057	5,081	4,656	97.96	189,751	245,940	18,016	5,186	3,585	159.48
3,000	129,439	126,847	18,679	5,256	4,817	95.01	189,753	245,940	18,637	5,365	3,709	154.47
3,100	129,440	126,847	19,302	5,432	4,977	92.26	189,755	245,940	19,258	5,544	3,832	149.78
3,200	129,442	126,847	19,925	5,607	5,138	89.67	189,758	245,940	19,880	5,723	3,956	145.39
3,300	129,444	126,847	20,547	5,782	5,298	87.25	189,760	245,940	20,501	5,902	4,079	141.27
3,400	129,445	126,847	21,170	5,957	5,459	84.96	189,762	245,940	21,122	6,080	4,203	137.38
3,500	129,447	126,847	21,793	6,133	5,619	82.81	189,765	245,940	21,743	6,259	4,327	133.72
3,600	129,449	126,847	22,415	6,308	5,780	80.78	189,767	245,940	22,365	6,438	4,450	130.27
3,700	129,450	126,847	23,038	6,483	5,940	78.85	189,769	245,940	22,986	6,617	4,574	127.00
3,800	129,452	126,847	23,661	6,658	6,101	77.03	189,772	245,940	23,607	6,796	4,697	123.90
3,900	129,454	126,847	24,283	6,833	6,262	75.30	189,774	245,940	24,228	6,974	4,821	120.96
4,000	129,455	126,847	24,906	7,009	6,422	73.66	189,776	245,940	24,850	7,153	4,945	118.17
5,000	129,472	126,847	31,132	8,761	8,028	60.85	189,800	245,940	31,062	8,942	6,181	96.38
6,000	129,489	126,847	37,359	10,513	9,633	52.31	189,823	245,940	37,274	10,730	7,417	81.86
7,000	129,506	126,847	43,585	12,265	11,239	46.21	189,847	245,940	43,487	12,518	8,653	71.49
8,000	129,522	126,847	49,812	14,017	12,844	41.63	189,870	245,940	49,699	14,306	9,889	63.71
9,000	129,539	126,847	56,038	15,769	14,450	38.07	189,894	245,940	55,912	16,095	11,126	57.66
10,000	129,556	126,847	62,265	17,521	16,055	35.22	189,917	245,940	62,124	17,883	12,362	52.82
11,000	129,573	126,847	68,491	19,273	17,661	32.89	189,941	245,940	68,337	19,671	13,598	48.86
12,000	129,589	126,847	74,717	21,025	19,266	30.95	189,964	245,940	74,549	21,459	14,834	45.56
13,000	129,606	126,847	80,944	22,777	20,872	29.31	189,988	245,940	80,761	23,248	16,070	42.77
14,000	129,623	126,847	87,170	24,529	22,477	27.90	190,011	245,940	86,974	25,036	17,307	40.38
15,000	129,640	126,847	93,397	26,281	24,083	26.68	190,035	245,940	93,186	26,824	18,543	38.30

* Costs not reported when sales exceed equipment capacity.

** Changes in fixed costs reflect assumed positive relationship between facility land values and sales density.

Appendix Table 4. Fixed and variable costs related to volume and radius of sales area for specified sizes of dry fertilizer custom application facilities for a 35 mile radius sales area, North Dakota, 1992.*

Annual sales (tons)	500 ton facility						800 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
	(-)					\$						-)
100	42,606	21,860	623	145	198	654.32	51,322	39,282	623	194	351	917.73
200	42,606	21,860	1,247	290	395	331.99	51,322	39,282	1,247	388	703	464.71
300	42,607	21,860	1,870	435	593	224.55	51,323	39,282	1,870	582	1,054	313.70
400	42,607	21,860	2,493	580	790	170.83	51,323	39,282	2,493	776	1,406	238.20
500	42,607	21,860	3,117	725	988	138.59	51,323	39,282	3,117	969	1,757	192.90
600	42,607	21,860	3,740	870	1,186	117.11	51,323	39,282	3,740	1,163	2,109	162.70
700	42,607	21,860	4,364	1,015	1,383	101.76	51,323	39,282	4,364	1,357	2,460	141.12
800	42,607	21,860	4,987	1,160	1,581	90.24	51,324	39,282	4,987	1,551	2,812	124.94
900	42,607	21,860	5,610	1,305	1,778	81.29	51,324	39,282	5,610	1,745	3,163	112.36
1,000	42,607	21,860	6,234	1,450	1,976	74.13	51,324	39,282	6,234	1,939	3,515	102.29
1,100	42,607	21,860	6,857	1,596	2,173	68.27	51,324	39,282	6,857	2,133	3,866	94.06
1,200	42,608	21,860	7,480	1,741	2,371	63.38	51,325	39,282	7,480	2,327	4,217	87.19
1,300	42,608	21,860	8,104	1,886	2,569	59.25	51,325	39,282	8,104	2,520	4,569	81.38
1,400	42,608	21,860	8,727	2,031	2,766	55.71	51,325	39,282	8,727	2,714	4,920	76.41
1,500	42,608	21,860	9,351	2,176	2,964	52.64	51,325	39,282	9,351	2,908	5,272	72.09
1,600	42,608	21,860	9,974	2,321	3,161	49.95	51,325	39,282	9,974	3,102	5,623	68.32
1,700	42,608	21,860	10,597	2,466	3,359	47.58	51,326	39,282	10,597	3,296	5,975	64.99
1,800	42,608	21,860	11,221	2,611	3,557	45.48	51,326	39,282	11,221	3,490	6,326	62.02
1,900	42,608	21,860	11,844	2,756	3,754	43.59	51,326	39,282	11,844	3,684	6,678	59.38
2,000	42,608	21,860	12,467	2,901	3,952	41.89	51,326	39,282	12,467	3,878	7,029	56.99
2,100	42,608	21,860	13,091	3,046	4,149	40.36	51,326	39,282	13,091	4,071	7,381	54.83
2,200	42,609	21,860	13,714	3,191	4,347	38.96	51,327	39,282	13,714	4,265	7,732	52.87
2,300	42,609	21,860	14,338	3,336	4,545	37.69	51,327	39,282	14,338	4,459	8,083	51.08
2,400	42,609	21,860	14,961	3,481	4,742	36.52	51,327	39,282	14,961	4,653	8,435	49.44
2,500	42,609	21,860	15,584	3,626	4,940	35.45	51,327	39,282	15,584	4,847	8,786	47.93
2,600	42,609	21,860	16,208	3,771	5,137	34.46	51,328	39,282	16,208	5,041	9,138	46.54
2,700	42,609	21,860	16,831	3,916	5,335	33.54	51,328	39,282	16,831	5,235	9,489	45.25
2,800	42,609	21,860	17,454	4,061	5,532	32.68	51,328	39,282	17,454	5,428	9,841	44.05
2,900	42,609	21,860	18,078	4,206	5,730	31.89	51,328	39,282	18,078	5,622	10,192	42.93
3,000	42,609	21,860	18,701	4,351	5,928	31.15	51,328	39,282	18,701	5,816	10,544	41.89
3,100	42,610	21,860	19,325	4,496	6,125	30.46	51,329	39,282	19,325	6,010	10,895	40.92
3,200	42,610	21,860	19,948	4,642	6,323	29.81	51,329	39,282	19,948	6,204	11,246	40.00
3,300	42,610	21,860	20,571	4,787	6,520	29.20	51,329	39,282	20,571	6,398	11,598	39.14
3,400	42,610	21,860	21,195	4,932	6,718	28.62	51,329	39,282	21,195	6,592	11,949	38.34
3,500	42,610	21,860	21,818	5,077	6,916	28.08	51,330	39,282	21,818	6,786	12,301	37.58
3,600	42,610	21,860	22,441	5,222	7,113	27.57	51,330	39,282	22,441	6,979	12,652	36.86
3,700	42,610	21,860	23,065	5,367	7,311	27.08	51,330	39,282	23,065	7,173	13,004	36.18
3,800	42,610	21,860	23,688	5,512	7,508	26.63	51,330	39,282	23,688	7,367	13,355	35.53
3,900	42,610	21,860	24,312	5,657	7,706	26.19	51,330	39,282	24,312	7,561	13,707	34.92
4,000	42,611	21,860	24,935	5,802	7,904	25.78	51,331	39,282	24,935	7,755	14,058	34.34
5,000	42,612	21,860	31,169	7,252	9,879	22.55	51,333	39,282	31,169	9,694	17,573	29.81

cont'd.

Appendix Table 4. (cont'd.)

Annual sales	1,300 ton facility						2,000 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(tons)	(-)	(-)	(-)	(-)	(-)	\$	(-)	(-)	(-)	(-)	(-)	(-)
100	99,131	77,151	623	178	313	1,773.97	121,638	126,847	623	185	287	2,495.80
200	99,132	77,151	1,246	356	626	892.55	121,638	126,847	1,246	369	575	1,253.38
300	99,132	77,151	1,868	534	939	598.75	121,639	126,847	1,868	554	862	839.24
400	99,132	77,151	2,491	713	1,251	451.85	121,639	126,847	2,491	738	1,150	632.16
500	99,133	77,151	3,114	891	1,564	363.71	121,640	126,847	3,114	923	1,437	507.92
600	99,133	77,151	3,737	1,069	1,877	304.94	121,641	126,847	3,737	1,107	1,724	425.09
700	99,133	77,151	4,359	1,247	2,190	262.97	121,641	126,847	4,359	1,292	2,012	365.93
800	99,134	77,151	4,982	1,425	2,503	231.49	121,642	126,847	4,982	1,476	2,299	321.56
900	99,134	77,151	5,605	1,603	2,816	207.01	121,642	126,847	5,605	1,661	2,586	287.05
1,000	99,134	77,151	6,228	1,781	3,129	187.42	121,643	126,847	6,228	1,845	2,874	259.44
1,100	99,135	77,151	6,851	1,959	3,442	171.40	121,643	126,847	6,851	2,030	3,161	236.85
1,200	99,135	77,151	7,473	2,137	3,754	158.04	121,644	126,847	7,473	2,215	3,449	218.02
1,300	99,135	77,151	8,096	2,315	4,067	146.74	121,644	126,847	8,096	2,399	3,736	202.09
1,400	99,136	77,151	8,719	2,493	4,380	137.06	121,645	126,847	8,719	2,584	4,023	188.44
1,500	99,136	77,151	9,342	2,672	4,693	128.66	121,645	126,847	9,342	2,768	4,311	176.61
1,600	99,136	77,151	9,964	2,850	5,006	121.32	121,646	126,847	9,964	2,953	4,598	166.26
1,700	99,137	77,151	10,587	3,028	5,319	114.84	121,647	126,847	10,587	3,137	4,885	157.12
1,800	99,137	77,151	11,210	3,206	5,632	109.08	121,647	126,847	11,210	3,322	5,173	149.00
1,900	99,137	77,151	11,833	3,384	5,945	103.92	121,648	126,847	11,833	3,506	5,460	141.73
2,000	99,138	77,151	12,456	3,562	6,257	99.28	121,648	126,847	12,456	3,691	5,748	135.19
2,100	99,138	77,151	13,078	3,740	6,570	95.08	121,649	126,847	13,078	3,875	6,035	129.28
2,200	99,138	77,151	13,701	3,918	6,883	91.27	121,649	126,847	13,701	4,060	6,322	123.90
2,300	99,139	77,151	14,324	4,096	7,196	87.79	121,650	126,847	14,324	4,244	6,610	118.99
2,400	99,139	77,151	14,947	4,274	7,509	84.59	121,650	126,847	14,947	4,429	6,897	114.49
2,500	99,139	77,151	15,570	4,452	7,822	81.65	121,651	126,847	15,570	4,613	7,185	110.35
2,600	99,140	77,151	16,192	4,631	8,135	78.94	121,651	126,847	16,192	4,798	7,472	106.52
2,700	99,140	77,151	16,815	4,809	8,447	76.43	121,652	126,847	16,815	4,982	7,759	102.98
2,800	99,140	77,151	17,438	4,987	8,760	74.10	121,653	126,847	17,438	5,167	8,047	99.70
2,900	99,141	77,151	18,061	5,165	9,073	71.93	121,653	126,847	18,061	5,352	8,334	96.64
3,000	99,141	77,151	18,683	5,343	9,386	69.90	121,654	126,847	18,683	5,536	8,621	93.78
3,100	99,141	77,151	19,306	5,521	9,699	68.01	121,654	126,847	19,306	5,721	8,909	91.11
3,200	99,142	77,151	19,929	5,699	10,012	66.23	121,655	126,847	19,929	5,905	9,196	88.60
3,300	99,142	77,151	20,552	5,877	10,325	64.56	121,655	126,847	20,552	6,090	9,484	86.25
3,400	99,142	77,151	21,175	6,055	10,638	62.99	121,656	126,847	21,175	6,274	9,771	84.04
3,500	99,143	77,151	21,797	6,233	10,950	61.51	121,656	126,847	21,797	6,459	10,058	81.95
3,600	99,143	77,151	22,420	6,411	11,263	60.11	121,657	126,847	22,420	6,643	10,346	79.98
3,700	99,143	77,151	23,043	6,590	11,576	58.78	121,657	126,847	23,043	6,828	10,633	78.11
3,800	99,144	77,151	23,666	6,768	11,889	57.53	121,658	126,847	23,666	7,012	10,920	76.34
3,900	99,144	77,151	24,288	6,946	12,202	56.34	121,659	126,847	24,288	7,197	11,208	74.67
4,000	99,144	77,151	24,911	7,124	12,515	55.21	121,659	126,847	24,911	7,381	11,495	73.07
5,000	99,148	77,151	31,139	8,905	15,643	46.40	121,665	126,847	31,139	9,227	14,369	60.65
6,000	99,151	77,151	37,367	10,686	18,772	40.52	121,670	126,847	37,367	11,072	17,243	52.37
7,000	99,154	77,151	43,595	12,467	21,901	36.32	121,676	126,847	43,595	12,917	20,117	46.45
8,000	99,157	77,151	49,822	14,247	25,030	33.18	121,681	126,847	49,822	14,763	22,990	42.01
9,000	99,161	77,151	56,050	16,028	28,158	30.73	121,687	126,847	56,050	16,608	25,864	38.56
10,000	99,164	77,151	62,278	17,809	31,287	28.77	121,692	126,847	62,278	18,453	28,738	35.80
11,000							121,697	126,847	68,506	20,299	31,612	33.54
12,000							121,703	126,847	74,734	22,144	34,486	31.66
13,000							121,708	126,847	80,961	23,989	37,359	30.07
14,000							121,714	126,847	87,189	25,834	40,233	28.70
15,000							121,719	126,847	93,417	27,680	43,107	27.52

cont'd.

Appendix Table 4. (cont'd.)

Annual sales	2,000 ton tower facility						4,000 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(tons)	(- - - - -)	(- - - - -)	(- - - - -)	(- - - - -)	(- - - - -)	\$	(- - - - -)	(- - - - -)	(- - - - -)	(- - - - -)	(- - - - -)	(- - - - -)
100	129,389	126,847	623	185	287	2,573.31	189,683	245,940	621	194	223	4,366.62
200	129,389	126,847	1,245	369	575	1,292.13	189,684	245,940	1,242	387	447	2,188.50
300	129,390	126,847	1,868	554	862	865.07	189,685	245,940	1,864	580	670	1,462.46
400	129,390	126,847	2,491	738	1,150	651.54	189,686	245,940	2,485	774	894	1,099.44
500	129,391	126,847	3,113	923	1,437	523.42	189,686	245,940	3,106	967	1,117	881.63
600	129,392	126,847	3,736	1,107	1,724	438.01	189,687	245,940	3,727	1,161	1,340	736.43
700	129,392	126,847	4,359	1,292	2,012	377.00	189,688	245,940	4,349	1,354	1,564	632.71
800	129,393	126,847	4,981	1,476	2,299	331.25	189,689	245,940	4,970	1,547	1,787	554.92
900	129,393	126,847	5,604	1,661	2,586	295.66	189,689	245,940	5,591	1,741	2,010	494.41
1,000	129,394	126,847	6,226	1,845	2,874	267.19	189,690	245,940	6,212	1,934	2,234	446.01
1,100	129,394	126,847	6,849	2,030	3,161	243.89	189,691	245,940	6,834	2,128	2,457	406.41
1,200	129,395	126,847	7,472	2,215	3,449	224.48	189,692	245,940	7,455	2,321	2,681	373.41
1,300	129,395	126,847	8,094	2,399	3,736	208.06	189,693	245,940	8,076	2,514	2,904	345.48
1,400	129,396	126,847	8,717	2,584	4,023	193.98	189,693	245,940	8,697	2,708	3,127	321.55
1,500	129,396	126,847	9,340	2,768	4,311	181.77	189,694	245,940	9,319	2,901	3,351	300.80
1,600	129,397	126,847	9,962	2,953	4,598	171.10	189,695	245,940	9,940	3,095	3,574	282.65
1,700	129,398	126,847	10,585	3,137	4,885	161.68	189,696	245,940	10,561	3,288	3,797	266.64
1,800	129,398	126,847	11,208	3,322	5,173	153.30	189,696	245,940	11,182	3,482	4,021	252.40
1,900	129,399	126,847	11,830	3,506	5,460	145.81	189,697	245,940	11,804	3,675	4,244	239.66
2,000	129,399	126,847	12,453	3,691	5,748	139.07	189,698	245,940	12,425	3,868	4,468	228.20
2,100	129,400	126,847	13,076	3,875	6,035	132.97	189,699	245,940	13,046	4,062	4,691	217.83
2,200	129,400	126,847	13,698	4,060	6,322	127.42	189,699	245,940	13,667	4,255	4,914	208.40
2,300	129,401	126,847	14,321	4,244	6,610	122.36	189,700	245,940	14,289	4,449	5,138	199.79
2,400	129,401	126,847	14,943	4,429	6,897	117.72	189,701	245,940	14,910	4,642	5,361	191.90
2,500	129,402	126,847	15,566	4,613	7,185	113.45	189,702	245,940	15,531	4,835	5,584	184.64
2,600	129,402	126,847	16,189	4,798	7,472	109.50	189,702	245,940	16,152	5,029	5,808	177.94
2,700	129,403	126,847	16,811	4,982	7,759	105.85	189,703	245,940	16,774	5,222	6,031	171.73
2,800	129,404	126,847	17,434	5,167	8,047	102.46	189,704	245,940	17,395	5,416	6,255	165.97
2,900	129,404	126,847	18,057	5,352	8,334	99.31	189,705	245,940	18,016	5,609	6,478	160.60
3,000	129,405	126,847	18,679	5,536	8,621	96.36	189,706	245,940	18,637	5,802	6,701	155.60
3,100	129,405	126,847	19,302	5,721	8,909	93.61	189,706	245,940	19,258	5,996	6,925	150.91
3,200	129,406	126,847	19,925	5,905	9,196	91.02	189,707	245,940	19,880	6,189	7,148	146.52
3,300	129,406	126,847	20,547	6,090	9,484	88.60	189,708	245,940	20,501	6,383	7,371	142.39
3,400	129,407	126,847	21,170	6,274	9,771	86.31	189,709	245,940	21,122	6,576	7,595	138.51
3,500	129,407	126,847	21,793	6,459	10,058	84.16	189,709	245,940	21,743	6,769	7,818	134.85
3,600	129,408	126,847	22,415	6,643	10,346	82.13	189,710	245,940	22,365	6,963	8,042	131.39
3,700	129,408	126,847	23,038	6,828	10,633	80.20	189,711	245,940	22,986	7,156	8,265	128.12
3,800	129,409	126,847	23,661	7,012	10,920	78.38	189,712	245,940	23,607	7,350	8,488	125.03
3,900	129,410	126,847	24,283	7,197	11,208	76.65	189,712	245,940	24,228	7,543	8,712	122.09
4,000	129,410	126,847	24,906	7,381	11,495	75.01	189,713	245,940	24,850	7,737	8,935	119.29
5,000	129,416	126,847	31,132	9,227	14,369	62.20	189,721	245,940	31,062	9,671	11,169	97.51
6,000	129,421	126,847	37,359	11,072	17,243	53.66	189,729	245,940	37,274	11,605	13,403	82.99
7,000	129,427	126,847	43,585	12,917	20,117	47.56	189,736	245,940	43,487	13,539	15,636	72.62
8,000	129,432	126,847	49,812	14,763	22,990	42.98	189,744	245,940	49,699	15,473	17,870	64.84
9,000	129,438	126,847	56,038	16,608	25,864	39.42	189,752	245,940	55,912	17,407	20,104	58.79
10,000	129,443	126,847	62,265	18,453	28,738	36.57	189,759	245,940	62,124	19,341	22,338	53.95
11,000	129,448	126,847	68,491	20,299	31,612	34.25	189,767	245,940	68,337	21,275	24,572	49.99
12,000	129,454	126,847	74,717	22,144	34,486	32.30	189,775	245,940	74,549	23,209	26,805	46.69
13,000	129,459	126,847	80,944	23,989	37,359	30.66	189,782	245,940	80,761	25,143	29,039	43.90
14,000	129,465	126,847	87,170	25,834	40,233	29.25	189,790	245,940	86,974	27,077	31,273	41.50
15,000	129,470	126,847	93,397	27,680	43,107	28.03	189,798	245,940	93,186	29,012	33,507	39.43

* Costs not reported when sales exceed equipment capacity.

** Changes in fixed costs reflect assumed positive relationship between facility land values and sales density.

Appendix Table 5. Fixed and variable costs related to volume and radius of sales area for specified sizes of dry fertilizer custom application facilities for a 50 mile radius sales area, North Dakota, 1992.*

Annual sales	500 ton facility						800 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(tons)	(-	-	-	-	-	\$	-	-	-	-	-	-
100	42,606	21,860	623	173	281	655.44	51,322	39,282	623	235	506	919.68
200	42,606	21,860	1,247	345	563	333.11	51,322	39,282	1,247	470	1,011	466.66
300	42,606	21,860	1,870	518	844	225.66	51,322	39,282	1,870	705	1,517	315.65
400	42,606	21,860	2,493	691	1,126	171.94	51,322	39,282	2,493	940	2,022	240.15
500	42,606	21,860	3,117	863	1,407	139.71	51,322	39,282	3,117	1,175	2,528	194.85
600	42,607	21,860	3,740	1,036	1,688	118.22	51,323	39,282	3,740	1,410	3,033	164.65
700	42,607	21,860	4,364	1,209	1,970	102.87	51,323	39,282	4,364	1,645	3,539	143.07
800	42,607	21,860	4,987	1,381	2,251	91.36	51,323	39,282	4,987	1,880	4,044	126.90
900	42,607	21,860	5,610	1,554	2,532	82.40	51,323	39,282	5,610	2,115	4,550	114.31
1,000	42,607	21,860	6,234	1,727	2,814	75.24	51,323	39,282	6,234	2,350	5,055	104.24
1,100	42,607	21,860	6,857	1,899	3,095	69.38	51,323	39,282	6,857	2,585	5,561	96.01
1,200	42,607	21,860	7,480	2,072	3,377	64.50	51,323	39,282	7,480	2,820	6,066	89.14
1,300	42,607	21,860	8,104	2,245	3,658	60.36	51,323	39,282	8,104	3,055	6,572	83.34
1,400	42,607	21,860	8,727	2,417	3,939	56.82	51,323	39,282	8,727	3,290	7,077	78.36
1,500	42,607	21,860	9,351	2,590	4,221	53.75	51,323	39,282	9,351	3,525	7,583	74.04
1,600	42,607	21,860	9,974	2,763	4,502	51.07	51,324	39,282	9,974	3,760	8,088	70.27
1,700	42,607	21,860	10,597	2,935	4,784	48.70	51,324	39,282	10,597	3,995	8,594	66.94
1,800	42,607	21,860	11,221	3,108	5,065	46.59	51,324	39,282	11,221	4,230	9,100	63.98
1,900	42,607	21,860	11,844	3,281	5,346	44.70	51,324	39,282	11,844	4,465	9,605	61.33
2,000	42,607	21,860	12,467	3,453	5,628	43.01	51,324	39,282	12,467	4,700	10,111	58.94
2,100	42,607	21,860	13,091	3,626	5,909	41.47	51,324	39,282	13,091	4,935	10,616	56.78
2,200	42,607	21,860	13,714	3,799	6,190	40.08	51,324	39,282	13,714	5,170	11,122	54.82
2,300	42,607	21,860	14,338	3,971	6,472	38.80	51,324	39,282	14,338	5,405	11,627	53.03
2,400	42,607	21,860	14,961	4,144	6,753	37.64	51,324	39,282	14,961	5,640	12,133	51.39
2,500	42,608	21,860	15,584	4,317	7,035	36.56	51,325	39,282	15,584	5,874	12,638	49.88
2,600	42,608	21,860	16,208	4,489	7,316	35.57	51,325	39,282	16,208	6,109	13,144	48.49
2,700	42,608	21,860	16,831	4,662	7,597	34.65	51,325	39,282	16,831	6,344	13,649	47.20
2,800	42,608	21,860	17,454	4,835	7,879	33.80	51,325	39,282	17,454	6,579	14,155	46.00
2,900	42,608	21,860	18,078	5,007	8,160	33.00	51,325	39,282	18,078	6,814	14,660	44.88
3,000	42,608	21,860	18,701	5,180	8,442	32.26	51,325	39,282	18,701	7,049	15,166	43.84
3,100	42,608	21,860	19,325	5,353	8,723	31.57	51,325	39,282	19,325	7,284	15,671	42.87
3,200	42,608	21,860	19,948	5,525	9,004	30.92	51,325	39,282	19,948	7,519	16,177	41.95
3,300	42,608	21,860	20,571	5,698	9,286	30.31	51,325	39,282	20,571	7,754	16,683	41.10
3,400	42,608	21,860	21,195	5,871	9,567	29.74	51,326	39,282	21,195	7,989	17,188	40.29
3,500	42,608	21,860	21,818	6,043	9,848	29.19	51,326	39,282	21,818	8,224	17,694	39.53

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Appendix Table 5. (cont'd.)

Annual sales	1,300 ton facility						2,000 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(tons)	(-	-	-	-	-	-	-	-	-	-	-	-)
100	99,131	77,151	623	219	451	1,775.75	121,638	126,847	623	231	414	2,497.53
200	99,131	77,151	1,246	438	901	894.34	121,638	126,847	1,246	462	828	1,255.11
300	99,132	77,151	1,868	657	1,352	600.53	121,638	126,847	1,868	693	1,243	840.96
400	99,132	77,151	2,491	876	1,802	453.63	121,638	126,847	2,491	924	1,657	633.89
500	99,132	77,151	3,114	1,095	2,253	365.49	121,639	126,847	3,114	1,155	2,071	509.65
600	99,132	77,151	3,737	1,314	2,704	306.73	121,639	126,847	3,737	1,385	2,485	426.82
700	99,132	77,151	4,359	1,533	3,154	264.76	121,639	126,847	4,359	1,616	2,899	367.66
800	99,132	77,151	4,982	1,752	3,605	233.28	121,639	126,847	4,982	1,847	3,314	323.29
900	99,133	77,151	5,605	1,971	4,055	208.79	121,640	126,847	5,605	2,078	3,728	288.78
1,000	99,133	77,151	6,228	2,190	4,506	189.21	121,640	126,847	6,228	2,309	4,142	261.17
1,100	99,133	77,151	6,851	2,409	4,957	173.18	121,640	126,847	6,851	2,540	4,556	238.58
1,200	99,133	77,151	7,473	2,628	5,407	159.83	121,640	126,847	7,473	2,771	4,971	219.75
1,300	99,133	77,151	8,096	2,847	5,858	148.53	121,641	126,847	8,096	3,002	5,385	203.82
1,400	99,133	77,151	8,719	3,066	6,308	138.84	121,641	126,847	8,719	3,232	5,799	190.17
1,500	99,134	77,151	9,342	3,285	6,759	130.45	121,641	126,847	9,342	3,463	6,213	178.34
1,600	99,134	77,151	9,964	3,504	7,210	123.10	121,642	126,847	9,964	3,694	6,627	167.98
1,700	99,134	77,151	10,587	3,723	7,660	116.62	121,642	126,847	10,587	3,925	7,042	158.85
1,800	99,134	77,151	11,210	3,942	8,111	110.86	121,642	126,847	11,210	4,156	7,456	150.73
1,900	99,134	77,151	11,833	4,161	8,561	105.71	121,642	126,847	11,833	4,387	7,870	143.46
2,000	99,134	77,151	12,456	4,380	9,012	101.07	121,643	126,847	12,456	4,618	8,284	136.92
2,100	99,134	77,151	13,078	4,599	9,463	96.87	121,643	126,847	13,078	4,849	8,698	131.01
2,200	99,135	77,151	13,701	4,818	9,913	93.05	121,643	126,847	13,701	5,080	9,113	125.63
2,300	99,135	77,151	14,324	5,037	10,364	89.57	121,643	126,847	14,324	5,310	9,527	120.72
2,400	99,135	77,151	14,947	5,256	10,814	86.38	121,644	126,847	14,947	5,541	9,941	116.22
2,500	99,135	77,151	15,570	5,475	11,265	83.44	121,644	126,847	15,570	5,772	10,355	112.08
2,600	99,135	77,151	16,192	5,694	11,716	80.73	121,644	126,847	16,192	6,003	10,769	108.25
2,700	99,135	77,151	16,815	5,913	12,166	78.22	121,644	126,847	16,815	6,234	11,184	104.71
2,800	99,136	77,151	17,438	6,132	12,617	75.88	121,645	126,847	17,438	6,465	11,598	101.43
2,900	99,136	77,151	18,061	6,351	13,067	73.71	121,645	126,847	18,061	6,696	12,012	98.37
3,000	99,136	77,151	18,683	6,570	13,518	71.69	121,645	126,847	18,683	6,927	12,426	95.51
3,100	99,136	77,151	19,306	6,789	13,969	69.79	121,646	126,847	19,306	7,157	12,840	92.84
3,200	99,136	77,151	19,929	7,008	14,419	68.01	121,646	126,847	19,929	7,388	13,255	90.33
3,300	99,136	77,151	20,552	7,227	14,870	66.34	121,646	126,847	20,552	7,619	13,669	87.98
3,400	99,137	77,151	21,175	7,446	15,320	64.77	121,646	126,847	21,175	7,850	14,083	85.77
3,500	99,137	77,151	21,797	7,665	15,771	63.29	121,647	126,847	21,797	8,081	14,497	83.68
3,600	99,137	77,151	22,420	7,884	16,222	61.89	121,647	126,847	22,420	8,312	14,912	81.70
3,700	99,137	77,151	23,043	8,103	16,672	60.57	121,647	126,847	23,043	8,543	15,326	79.84
3,800	99,137	77,151	23,666	8,322	17,123	59.32	121,647	126,847	23,666	8,774	15,740	78.07
3,900	99,137	77,151	24,288	8,541	17,573	58.13	121,648	126,847	24,288	9,004	16,154	76.40
4,000	99,138	77,151	24,911	8,760	18,024	57.00	121,648	126,847	24,911	9,235	16,568	74.80
5,000	99,139	77,151	31,139	10,951	22,530	48.18	121,651	126,847	31,139	11,544	20,710	62.38
6,000	99,141	77,151	37,367	13,141	27,036	42.31	121,653	126,847	37,367	13,853	24,853	54.10
7,000	99,142	77,151	43,595	15,331	31,542	38.11	121,656	126,847	43,595	16,162	28,995	48.18
8,000							121,659	126,847	49,822	18,471	33,137	43.74
9,000							121,661	126,847	56,050	20,779	37,279	40.29
10,000							121,664	126,847	62,278	23,088	41,421	37.53
11,000							121,667	126,847	68,506	25,397	45,563	35.27

cont'd.

Appendix Table 5. (cont'd.)

Annual sales	2,000 ton tower facility						4,000 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(tons)	(-	-	-	-	-	\$	-	-	-	-	-)
100	129,389	126,847	623	231	414	2,575.04	189,683	245,940	621	246	323	4,368.14
200	129,389	126,847	1,245	462	828	1,293.86	189,683	245,940	1,242	492	646	2,190.02
300	129,389	126,847	1,868	693	1,243	866.80	189,684	245,940	1,864	738	969	1,463.98
400	129,389	126,847	2,491	924	1,657	653.27	189,684	245,940	2,485	984	1,293	1,100.96
500	129,390	126,847	3,113	1,155	2,071	525.15	189,684	245,940	3,106	1,230	1,616	883.15
600	129,390	126,847	3,736	1,385	2,485	439.74	189,685	245,940	3,727	1,476	1,939	737.95
700	129,390	126,847	4,359	1,616	2,899	378.73	189,685	245,940	4,349	1,722	2,262	634.23
800	129,390	126,847	4,981	1,847	3,314	332.97	189,686	245,940	4,970	1,968	2,585	556.44
900	129,391	126,847	5,604	2,078	3,728	297.39	189,686	245,940	5,591	2,214	2,908	495.93
1,000	129,391	126,847	6,226	2,309	4,142	268.92	189,686	245,940	6,212	2,461	3,231	447.53
1,100	129,391	126,847	6,849	2,540	4,556	245.62	189,687	245,940	6,834	2,707	3,555	407.93
1,200	129,391	126,847	7,472	2,771	4,971	226.21	189,687	245,940	7,455	2,953	3,878	374.93
1,300	129,392	126,847	8,094	3,002	5,385	209.78	189,687	245,940	8,076	3,199	4,201	347.00
1,400	129,392	126,847	8,717	3,232	5,799	195.71	189,688	245,940	8,697	3,445	4,524	323.07
1,500	129,392	126,847	9,340	3,463	6,213	183.50	189,688	245,940	9,319	3,691	4,847	302.32
1,600	129,393	126,847	9,962	3,694	6,627	172.83	189,689	245,940	9,940	3,937	5,170	284.17
1,700	129,393	126,847	10,585	3,925	7,042	163.41	189,689	245,940	10,561	4,183	5,493	268.16
1,800	129,393	126,847	11,208	4,156	7,456	155.03	189,689	245,940	11,182	4,429	5,816	253.92
1,900	129,393	126,847	11,830	4,387	7,870	147.54	189,690	245,940	11,804	4,675	6,140	241.18
2,000	129,394	126,847	12,453	4,618	8,284	140.80	189,690	245,940	12,425	4,921	6,463	229.72
2,100	129,394	126,847	13,076	4,849	8,698	134.70	189,690	245,940	13,046	5,167	6,786	219.35
2,200	129,394	126,847	13,698	5,080	9,113	129.15	189,691	245,940	13,667	5,413	7,109	209.92
2,300	129,394	126,847	14,321	5,310	9,527	124.09	189,691	245,940	14,289	5,659	7,432	201.31
2,400	129,395	126,847	14,943	5,541	9,941	119.44	189,692	245,940	14,910	5,905	7,755	193.42
2,500	129,395	126,847	15,566	5,772	10,355	115.17	189,692	245,940	15,531	6,151	8,078	186.16
2,600	129,395	126,847	16,189	6,003	10,769	111.23	189,692	245,940	16,152	6,397	8,402	179.46
2,700	129,395	126,847	16,811	6,234	11,184	107.58	189,693	245,940	16,774	6,643	8,725	173.25
2,800	129,396	126,847	17,434	6,465	11,598	104.19	189,693	245,940	17,395	6,889	9,048	167.49
2,900	129,396	126,847	18,057	6,696	12,012	101.04	189,693	245,940	18,016	7,135	9,371	162.12
3,000	129,396	126,847	18,679	6,927	12,426	98.09	189,694	245,940	18,637	7,381	9,694	157.12
3,100	129,397	126,847	19,302	7,157	12,840	95.34	189,694	245,940	19,258	7,627	10,017	152.43
3,200	129,397	126,847	19,925	7,388	13,255	92.75	189,695	245,940	19,880	7,873	10,340	148.04
3,300	129,397	126,847	20,547	7,619	13,669	90.33	189,695	245,940	20,501	8,119	10,664	143.91
3,400	129,397	126,847	21,170	7,850	14,083	88.04	189,695	245,940	21,122	8,365	10,987	140.03
3,500	129,398	126,847	21,793	8,081	14,497	85.89	189,696	245,940	21,743	8,612	11,310	136.37
3,600	129,398	126,847	22,415	8,312	14,912	83.86	189,696	245,940	22,365	8,858	11,633	132.91
3,700	129,398	126,847	23,038	8,543	15,326	81.93	189,696	245,940	22,986	9,104	11,956	129.64
3,800	129,398	126,847	23,661	8,774	15,740	80.11	189,697	245,940	23,607	9,350	12,279	126.55
3,900	129,399	126,847	24,283	9,004	16,154	78.38	189,697	245,940	24,228	9,596	12,602	123.61
4,000	129,399	126,847	24,906	9,235	16,568	76.74	189,698	245,940	24,850	9,842	12,926	120.81
5,000	129,402	126,847	31,132	11,544	20,710	63.93	189,701	245,940	31,062	12,302	16,157	99.03
6,000	129,404	126,847	37,359	13,853	24,853	55.39	189,705	245,940	37,274	14,763	19,388	84.51
7,000	129,407	126,847	43,585	16,162	28,995	49.29	189,709	245,940	43,487	17,223	22,620	74.14
8,000	129,410	126,847	49,812	18,471	33,137	44.71	189,713	245,940	49,699	19,683	25,851	66.36
9,000	129,412	126,847	56,038	20,779	37,279	41.15	189,716	245,940	55,912	22,144	29,082	60.31
10,000	129,415	126,847	62,265	23,088	41,421	38.30	189,720	245,940	62,124	24,604	32,314	55.47
11,000	129,418	126,847	68,491	25,397	45,563	35.97	189,724	245,940	68,337	27,065	35,545	51.51
12,000							189,728	245,940	74,549	29,525	38,777	48.21
13,000							189,731	245,940	80,761	31,985	42,008	45.42
14,000							189,735	245,940	86,974	34,446	45,239	43.02
15,000							189,739	245,940	93,186	36,906	48,471	40.95

* Costs not reported when sales exceed equipment capacity.

** Changes in fixed costs reflect assumed positive relationship between facility land values and sales density.

Appendix Table 6. Fixed and variable costs related to volume and radius of sales area for specified sizes of dry fertilizer custom application for a 5 mile radius sales area, western North Dakota, 1992.

Annual sales	500 ton facility						800 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(tons)	(- - - - -)											(- - - - -)
100	42,612	13,890	623	57	13	571.95	45,559	18,348	623	57	13	646.00
200	42,617	13,890	1,247	113	27	289.47	45,570	18,348	1,247	113	27	326.52
300	42,622	13,890	1,870	170	40	195.31	45,581	18,348	1,870	170	40	220.03
400	42,628	13,890	2,493	226	54	148.23	45,592	18,348	2,493	226	54	166.78
500	42,633	13,890	3,117	283	67	119.98	45,602	18,348	3,117	283	67	134.83
600	42,638	13,890	3,740	339	81	101.15	45,613	18,348	3,740	339	81	113.53
700	42,644	13,890	4,364	396	94	87.70	45,624	18,348	4,364	396	94	98.32
800	42,649	13,890	4,987	452	108	77.61	45,635	18,348	4,987	452	108	86.91
900	42,654	13,890	5,610	509	121	69.76	45,645	18,348	5,610	509	121	78.04
1,000	42,660	13,890	6,234	565	135	63.48	45,656	18,348	6,234	565	135	70.94
1,100	42,665	13,890	6,857	622	148	58.35	45,667	18,348	6,857	622	148	65.13
1,200	42,671	13,890	7,480	678	162	54.07	45,677	18,348	7,480	678	162	60.29
1,300	42,676	13,890	8,104	735	175	50.45	45,688	18,348	8,104	735	175	56.19
1,400	42,681	13,890	8,727	792	189	47.34	45,699	18,348	8,727	792	189	52.68
1,500	42,687	13,890	9,351	848	202	44.65	45,710	18,348	9,351	848	202	49.64
1,600	42,692	13,890	9,974	905	216	42.30	45,720	18,348	9,974	905	216	46.98
1,700	42,697	13,890	10,597	961	229	40.22	45,731	18,348	10,597	961	229	44.63
1,800	42,703	13,890	11,221	1,018	243	38.37	45,742	18,348	11,221	1,018	243	42.54
1,900	42,708	13,890	11,844	1,074	256	36.72	45,753	18,348	11,844	1,074	256	40.67
2,000	42,714	13,890	12,467	1,131	270	35.24	45,763	18,348	12,467	1,131	270	38.99
2,100	42,719	13,890	13,091	1,187	283	33.89	45,774	18,348	13,091	1,187	283	37.47
2,200	42,724	13,890	13,714	1,244	297	32.67	45,785	18,348	13,714	1,244	297	36.08
2,300	42,730	13,890	14,338	1,300	310	31.55	45,795	18,348	14,338	1,300	310	34.82
2,400	42,735	13,890	14,961	1,357	324	30.53	45,806	18,348	14,961	1,357	324	33.66
2,500	42,740	13,890	15,584	1,414	337	29.59	45,817	18,348	15,584	1,414	337	32.60
2,600	42,746	13,890	16,208	1,470	350	28.72	45,828	18,348	16,208	1,470	350	31.62
2,700	42,751	13,890	16,831	1,527	364	27.91	45,838	18,348	16,831	1,527	364	30.71
2,800	42,756	13,890	17,454	1,583	377	27.16	45,849	18,348	17,454	1,583	377	29.86
2,900	42,762	13,890	18,078	1,640	391	26.47	45,860	18,348	18,078	1,640	391	29.07
3,000	42,767	13,890	18,701	1,696	404	25.82	45,871	18,348	18,701	1,696	404	28.34
3,100	42,773	13,890	19,325	1,753	418	25.21	45,881	18,348	19,325	1,753	418	27.65
3,200	42,778	13,890	19,948	1,809	431	24.64	45,892	18,348	19,948	1,809	431	27.01
3,300	42,783	13,890	20,571	1,866	445	24.11	45,903	18,348	20,571	1,866	445	26.40
3,400	42,789	13,890	21,195	1,922	458	23.60	45,914	18,348	21,195	1,922	458	25.83
3,500	42,794	13,890	21,818	1,979	472	23.13	45,924	18,348	21,818	1,979	472	25.30
3,600	42,799	13,890	22,441	2,035	485	22.68	45,935	18,348	22,441	2,035	485	24.79
3,700	42,805	13,890	23,065	2,092	499	22.26	45,946	18,348	23,065	2,092	499	24.31
3,800	42,810	13,890	23,688	2,149	512	21.86	45,956	18,348	23,688	2,149	512	23.86
3,900	42,815	13,890	24,312	2,205	526	21.47	45,967	18,348	24,312	2,205	526	23.42
4,000	42,821	13,890	24,935	2,262	539	21.11	45,978	18,348	24,935	2,262	539	23.02
5,000	42,874	13,890	31,169	2,827	674	18.29	46,085	18,348	31,169	2,827	674	19.82
6,000	42,928	13,890	37,402	3,392	809	16.40	46,193	18,348	37,402	3,392	809	17.69
7,000	42,982	13,890	43,636	3,958	944	15.06	46,300	18,348	43,636	3,958	944	16.17
8,000	43,035	13,890	49,870	4,523	1,078	14.05	46,407	18,348	49,870	4,523	1,078	15.03
9,000	43,089	13,890	56,104	5,089	1,213	13.26	46,515	18,348	56,104	5,089	1,213	14.14
10,000	43,143	13,890	62,337	5,654	1,348	12.64	46,622	18,348	62,337	5,654	1,348	13.43
11,000	43,196	13,890	68,571	6,219	1,483	12.12	46,729	18,348	68,571	6,219	1,483	12.85
12,000	43,250	13,890	74,805	6,785	1,618	11.70	46,837	18,348	74,805	6,785	1,618	12.37
13,000	43,304	13,890	81,039	7,350	1,752	11.33	46,944	18,348	81,039	7,350	1,752	11.96
14,000	43,357	13,890	87,272	7,916	1,887	11.02	47,051	18,348	87,272	7,916	1,887	11.61
15,000	43,411	13,890	93,506	8,481	2,022	10.75	47,158	18,348	93,506	8,481	2,022	11.30

cont'd.

Appendix Table 6. (cont'd.)

Annual sales	1,300 ton facility						2,000 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(tons)	(-	-	-	-	-	-	\$	-	-	-	-	-)
100	99,147	18,348	623	57	13	1,181.88	121,664	45,816	623	78	28	1,682.09
200	99,163	18,348	1,246	113	27	594.48	121,691	45,816	1,246	157	56	844.82
300	99,179	18,348	1,868	170	40	398.68	121,718	45,816	1,868	235	83	565.74
400	99,195	18,348	2,491	226	54	300.79	121,745	45,816	2,491	313	111	426.19
500	99,212	18,348	3,114	283	67	242.05	121,771	45,816	3,114	391	139	342.46
600	99,228	18,348	3,737	339	81	202.89	121,798	45,816	3,737	469	167	286.65
700	99,244	18,348	4,359	396	94	174.92	121,825	45,816	4,359	548	194	246.78
800	99,260	18,348	4,982	452	108	153.94	121,852	45,816	4,982	626	222	216.87
900	99,276	18,348	5,605	509	121	137.62	121,879	45,816	5,605	704	250	193.62
1,000	99,292	18,348	6,228	565	135	124.57	121,906	45,816	6,228	782	278	175.01
1,100	99,308	18,348	6,851	622	148	113.89	121,932	45,816	6,851	860	306	159.79
1,200	99,324	18,348	7,473	678	162	104.99	121,959	45,816	7,473	939	333	147.10
1,300	99,340	18,348	8,096	735	175	97.46	121,986	45,816	8,096	1,017	361	136.37
1,400	99,356	18,348	8,719	792	189	91.00	122,013	45,816	8,719	1,095	389	127.17
1,500	99,373	18,348	9,342	848	202	85.41	122,040	45,816	9,342	1,173	417	119.19
1,600	99,389	18,348	9,964	905	216	80.51	122,067	45,816	9,964	1,251	444	112.21
1,700	99,405	18,348	10,587	961	229	76.19	122,093	45,816	10,587	1,330	472	106.06
1,800	99,421	18,348	11,210	1,018	243	72.35	122,120	45,816	11,210	1,408	500	100.59
1,900	99,437	18,348	11,833	1,074	256	68.92	122,147	45,816	11,833	1,486	528	95.69
2,000	99,453	18,348	12,456	1,131	270	65.83	122,174	45,816	12,456	1,564	556	91.28
2,100	99,469	18,348	13,078	1,187	283	63.03	122,201	45,816	13,078	1,643	583	87.30
2,200	99,485	18,348	13,701	1,244	297	60.49	122,228	45,816	13,701	1,721	611	83.67
2,300	99,501	18,348	14,324	1,300	310	58.17	122,254	45,816	14,324	1,799	639	80.36
2,400	99,517	18,348	14,947	1,357	324	56.04	122,281	45,816	14,947	1,877	667	77.33
2,500	99,534	18,348	15,570	1,414	337	54.08	122,308	45,816	15,570	1,955	694	74.54
2,600	99,550	18,348	16,192	1,470	350	52.27	122,335	45,816	16,192	2,034	722	71.96
2,700	99,566	18,348	16,815	1,527	364	50.60	122,362	45,816	16,815	2,112	750	69.58
2,800	99,582	18,348	17,438	1,583	377	49.05	122,388	45,816	17,438	2,190	778	67.36
2,900	99,598	18,348	18,061	1,640	391	47.60	122,415	45,816	18,061	2,268	805	65.30
3,000	99,614	18,348	18,683	1,696	404	46.25	122,442	45,816	18,683	2,346	833	63.37
3,100	99,630	18,348	19,306	1,753	418	44.99	122,469	45,816	19,306	2,425	861	61.57
3,200	99,646	18,348	19,929	1,809	431	43.80	122,496	45,816	19,929	2,503	889	59.89
3,300	99,662	18,348	20,552	1,866	445	42.69	122,523	45,816	20,552	2,581	917	58.30
3,400	99,678	18,348	21,175	1,922	458	41.64	122,549	45,816	21,175	2,659	944	56.81
3,500	99,695	18,348	21,797	1,979	472	40.65	122,576	45,816	21,797	2,738	972	55.40
3,600	99,711	18,348	22,420	2,035	485	39.72	122,603	45,816	22,420	2,816	1,000	54.07
3,700	99,727	18,348	23,043	2,092	499	38.84	122,630	45,816	23,043	2,894	1,028	52.81
3,800	99,743	18,348	23,666	2,149	512	38.00	122,657	45,816	23,666	2,972	1,055	51.62
3,900	99,759	18,348	24,288	2,205	526	37.21	122,684	45,816	24,288	3,050	1,083	50.49
4,000	99,775	18,348	24,911	2,262	539	36.46	122,710	45,816	24,911	3,129	1,111	49.42
5,000	99,936	18,348	31,139	2,827	674	30.58	122,979	45,816	31,139	3,911	1,389	41.05
6,000	100,097	18,348	37,367	3,392	809	26.67	123,247	45,816	37,367	4,693	1,667	35.46
7,000	100,258	18,348	43,595	3,958	944	23.87	123,515	45,816	43,595	5,475	1,944	31.48
8,000	100,419	18,348	49,822	4,523	1,078	21.77	123,784	45,816	49,822	6,257	2,222	28.49
9,000	100,580	18,348	56,050	5,089	1,213	20.14	124,052	45,816	56,050	7,039	2,500	26.16
10,000	100,741	18,348	62,278	5,654	1,348	18.84	124,320	45,816	62,278	7,821	2,778	24.30
11,000	100,902	18,348	68,506	6,219	1,483	17.77	124,589	45,816	68,506	8,603	3,055	22.78
12,000	101,063	18,348	74,734	6,785	1,618	16.88	124,857	45,816	74,734	9,386	3,333	21.51
13,000	101,224	18,348	80,961	7,350	1,752	16.13	125,125	45,816	80,961	10,168	3,611	20.44
14,000	101,385	18,348	87,189	7,916	1,887	15.48	125,394	45,816	87,189	10,950	3,889	19.52
15,000	101,546	18,348	93,417	8,481	2,022	14.92	125,662	45,816	93,417	11,732	4,166	18.72

cont'd.

Appendix Table 6. (cont'd.)

Annual sales	2,000 ton tower facility						4,000 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(tons)	(-	-	-	-	-	-	-	-	-	-	-	-)
100	129,415	45,816	623	78	28	1,759.60	189,720	92,206	621	75	25	2,826.47
200	129,442	45,816	1,245	157	56	883.58	189,758	92,206	1,242	149	50	1,417.03
300	129,469	45,816	1,868	235	83	591.57	189,795	92,206	1,864	224	76	947.22
400	129,496	45,816	2,491	313	111	445.57	189,833	92,206	2,485	299	101	712.31
500	129,522	45,816	3,113	391	139	357.96	189,870	92,206	3,106	373	126	571.36
600	129,549	45,816	3,736	469	167	299.56	189,908	92,206	3,727	448	151	477.40
700	129,576	45,816	4,359	548	194	257.85	189,945	92,206	4,349	523	177	410.28
800	129,603	45,816	4,981	626	222	226.56	189,983	92,206	4,970	597	202	359.95
900	129,630	45,816	5,604	704	250	202.23	190,021	92,206	5,591	672	227	320.80
1,000	129,657	45,816	6,226	782	278	182.76	190,058	92,206	6,212	746	252	289.48
1,100	129,683	45,816	6,849	860	306	166.83	190,096	92,206	6,834	821	278	263.85
1,200	129,710	45,816	7,472	939	333	153.56	190,133	92,206	7,455	896	303	242.49
1,300	129,737	45,816	8,094	1,017	361	142.33	190,171	92,206	8,076	970	328	224.42
1,400	129,764	45,816	8,717	1,095	389	132.70	190,208	92,206	8,697	1,045	353	208.94
1,500	129,791	45,816	9,340	1,173	417	124.36	190,246	92,206	9,319	1,120	379	195.51
1,600	129,818	45,816	9,962	1,251	444	117.06	190,284	92,206	9,940	1,194	404	183.77
1,700	129,844	45,816	10,585	1,330	472	110.62	190,321	92,206	10,561	1,269	429	173.40
1,800	129,871	45,816	11,208	1,408	500	104.89	190,359	92,206	11,182	1,344	454	164.19
1,900	129,898	45,816	11,830	1,486	528	99.77	190,396	92,206	11,804	1,418	479	155.95
2,000	129,925	45,816	12,453	1,564	556	95.16	190,434	92,206	12,425	1,493	505	148.53
2,100	129,952	45,816	13,076	1,643	583	90.99	190,471	92,206	13,046	1,567	530	141.82
2,200	129,979	45,816	13,698	1,721	611	87.19	190,509	92,206	13,667	1,642	555	135.72
2,300	130,005	45,816	14,321	1,799	639	83.73	190,546	92,206	14,289	1,717	580	130.15
2,400	130,032	45,816	14,943	1,877	667	80.56	190,584	92,206	14,910	1,791	606	125.04
2,500	130,059	45,816	15,566	1,955	694	77.64	190,622	92,206	15,531	1,866	631	120.34
2,600	130,086	45,816	16,189	2,034	722	74.94	190,659	92,206	16,152	1,941	656	116.01
2,700	130,113	45,816	16,811	2,112	750	72.45	190,697	92,206	16,774	2,015	681	111.99
2,800	130,139	45,816	17,434	2,190	778	70.13	190,734	92,206	17,395	2,090	707	108.26
2,900	130,166	45,816	18,057	2,268	805	67.97	190,772	92,206	18,016	2,165	732	104.79
3,000	130,193	45,816	18,679	2,346	833	65.96	190,809	92,206	18,637	2,239	757	101.55
3,100	130,220	45,816	19,302	2,425	861	64.07	190,847	92,206	19,258	2,314	782	98.52
3,200	130,247	45,816	19,925	2,503	889	62.31	190,885	92,206	19,880	2,389	807	95.68
3,300	130,274	45,816	20,547	2,581	917	60.65	190,922	92,206	20,501	2,463	833	93.01
3,400	130,300	45,816	21,170	2,659	944	59.09	190,960	92,206	21,122	2,538	858	90.50
3,500	130,327	45,816	21,793	2,738	972	57.61	190,997	92,206	21,743	2,612	883	88.13
3,600	130,354	45,816	22,415	2,816	1,000	56.22	191,035	92,206	22,365	2,687	908	85.89
3,700	130,381	45,816	23,038	2,894	1,028	54.91	191,072	92,206	22,986	2,762	934	83.77
3,800	130,408	45,816	23,661	2,972	1,055	53.66	191,110	92,206	23,607	2,836	959	81.77
3,900	130,435	45,816	24,283	3,050	1,083	52.48	191,147	92,206	24,228	2,911	984	79.87
4,000	130,461	45,816	24,906	3,129	1,111	51.36	191,185	92,206	24,850	2,986	1,009	78.06
5,000	130,730	45,816	31,132	3,911	1,389	42.60	191,561	92,206	31,062	3,732	1,262	63.96
6,000	130,998	45,816	37,359	4,693	1,667	36.76	191,936	92,206	37,274	4,478	1,514	54.57
7,000	131,266	45,816	43,585	5,475	1,944	32.58	192,312	92,206	43,487	5,225	1,766	47.86
8,000	131,535	45,816	49,812	6,257	2,222	29.46	192,688	92,206	49,699	5,971	2,019	42.82
9,000	131,803	45,816	56,038	7,039	2,500	27.02	193,063	92,206	55,912	6,717	2,271	38.91
10,000	132,071	45,816	62,265	7,821	2,778	25.08	193,439	92,206	62,124	7,464	2,523	35.78
11,000	132,340	45,816	68,491	8,603	3,055	23.48	193,814	92,206	68,337	8,210	2,776	33.21
12,000	132,608	45,816	74,717	9,386	3,333	22.16	194,190	92,206	74,549	8,957	3,028	31.08
13,000	132,876	45,816	80,944	10,168	3,611	21.03	194,566	92,206	80,761	9,703	3,280	29.27
14,000	133,145	45,816	87,170	10,950	3,889	20.07	194,941	92,206	86,974	10,449	3,533	27.72
15,000	133,413	45,816	93,397	11,732	4,166	19.23	195,317	92,206	93,186	11,196	3,785	26.38

* Costs not reported when sales exceed equipment capacity.

** Changes in fixed costs reflect assumed positive relationship between facility land values and sales density.

Appendix Table 7. Fixed and variable costs related to volume and radius of sales area for specified sizes of dry fertilizer custom application for a 12.5 mile radius sales area, western North Dakota, 1992.

Annual sales	500 ton facility						800 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(tons)	(-	-	-	-	-	-	(-	-	-	-	-	-
100	42,607	13,890	623	56	30	572.06	45,550	18,348	623	56	30	646.07
200	42,608	13,890	1,247	111	60	289.58	45,552	18,348	1,247	111	60	326.59
300	42,609	13,890	1,870	167	90	195.42	45,554	18,348	1,870	167	90	220.09
400	42,610	13,890	2,493	222	120	148.34	45,556	18,348	2,493	222	120	166.85
500	42,610	13,890	3,117	278	151	120.09	45,557	18,348	3,117	278	151	134.90
600	42,611	13,890	3,740	333	181	101.26	45,559	18,348	3,740	333	181	113.60
700	42,612	13,890	4,364	389	211	87.81	45,561	18,348	4,364	389	211	98.39
800	42,613	13,890	4,987	444	241	77.72	45,562	18,348	4,987	444	241	86.98
900	42,614	13,890	5,610	500	271	69.87	45,564	18,348	5,610	500	271	78.10
1,000	42,615	13,890	6,234	555	301	63.60	45,566	18,348	6,234	555	301	71.00
1,100	42,616	13,890	6,857	611	331	58.46	45,568	18,348	6,857	611	331	65.19
1,200	42,616	13,890	7,480	666	361	54.18	45,569	18,348	7,480	666	361	60.35
1,300	42,617	13,890	8,104	722	391	50.56	45,571	18,348	8,104	722	391	56.26
1,400	42,618	13,890	8,727	778	421	47.45	45,573	18,348	8,727	778	421	52.75
1,500	42,619	13,890	9,351	833	452	44.76	45,574	18,348	9,351	833	452	49.70
1,600	42,620	13,890	9,974	889	482	42.41	45,576	18,348	9,974	889	482	47.04
1,700	42,621	13,890	10,597	944	512	40.33	45,578	18,348	10,597	944	512	44.69
1,800	42,622	13,890	11,221	1,000	542	38.49	45,580	18,348	11,221	1,000	542	42.61
1,900	42,622	13,890	11,844	1,055	572	36.83	45,581	18,348	11,844	1,055	572	40.74
2,000	42,623	13,890	12,467	1,111	602	35.35	45,583	18,348	12,467	1,111	602	39.06
2,100	42,624	13,890	13,091	1,166	632	34.00	45,585	18,348	13,091	1,166	632	37.53
2,200	42,625	13,890	13,714	1,222	662	32.78	45,586	18,348	13,714	1,222	662	36.15
2,300	42,626	13,890	14,338	1,277	692	31.66	45,588	18,348	14,338	1,277	692	34.89
2,400	42,627	13,890	14,961	1,333	722	30.64	45,590	18,348	14,961	1,333	722	33.73
2,500	42,628	13,890	15,584	1,388	753	29.70	45,592	18,348	15,584	1,388	753	32.67
2,600	42,629	13,890	16,208	1,444	783	28.83	45,593	18,348	16,208	1,444	783	31.68
2,700	42,629	13,890	16,831	1,499	813	28.02	45,595	18,348	16,831	1,499	813	30.77
2,800	42,630	13,890	17,454	1,555	843	27.28	45,597	18,348	17,454	1,555	843	29.93
2,900	42,631	13,890	18,078	1,611	873	26.58	45,598	18,348	18,078	1,611	873	29.14
3,000	42,632	13,890	18,701	1,666	903	25.93	45,600	18,348	18,701	1,666	903	28.41
3,100	42,633	13,890	19,325	1,722	933	25.32	45,602	18,348	19,325	1,722	933	27.72
3,200	42,634	13,890	19,948	1,777	963	24.75	45,604	18,348	19,948	1,777	963	27.07
3,300	42,635	13,890	20,571	1,833	993	24.22	45,605	18,348	20,571	1,833	993	26.47
3,400	42,635	13,890	21,195	1,888	1,024	23.72	45,607	18,348	21,195	1,888	1,024	25.90
3,500	42,636	13,890	21,818	1,944	1,054	23.24	45,609	18,348	21,818	1,944	1,054	25.36
3,600	42,637	13,890	22,441	1,999	1,084	22.79	45,610	18,348	22,441	1,999	1,084	24.86
3,700	42,638	13,890	23,065	2,055	1,114	22.37	45,612	18,348	23,065	2,055	1,114	24.38
3,800	42,639	13,890	23,688	2,110	1,144	21.97	45,614	18,348	23,688	2,110	1,144	23.92
3,900	42,640	13,890	24,312	2,166	1,174	21.59	45,616	18,348	24,312	2,166	1,174	23.49
4,000	42,641	13,890	24,935	2,221	1,204	21.22	45,617	18,348	24,935	2,221	1,204	23.08
5,000	42,649	13,890	31,169	2,777	1,505	18.40	45,635	18,348	31,169	2,777	1,505	19.89
6,000	42,658	13,890	37,402	3,332	1,806	16.51	45,652	18,348	37,402	3,332	1,806	17.76
7,000	42,666	13,890	43,636	3,888	2,107	15.17	45,669	18,348	43,636	3,888	2,107	16.24
8,000	42,675	13,890	49,870	4,443	2,408	14.16	45,686	18,348	49,870	4,443	2,408	15.09
9,000	42,683	13,890	56,104	4,998	2,709	13.38	45,703	18,348	56,104	4,998	2,709	14.21
10,000	42,692	13,890	62,337	5,554	3,010	12.75	45,720	18,348	62,337	5,554	3,010	13.50
11,000	42,701	13,890	68,571	6,109	3,311	12.23	45,738	18,348	68,571	6,109	3,311	12.92
12,000	42,709	13,890	74,805	6,664	3,612	11.81	45,755	18,348	74,805	6,664	3,612	12.43
13,000	42,718	13,890	81,039	7,220	3,913	11.44	45,772	18,348	81,039	7,220	3,913	12.02
14,000	42,726	13,890	87,272	7,775	4,215	11.13	45,789	18,348	87,272	7,775	4,215	11.67
15,000	42,735	13,890	93,506	8,330	4,516	10.87	45,806	18,348	93,506	8,330	4,516	11.37

cont'd.

Appendix Table 7. (cont'd.)

Annual sales	1,300 ton facility						2,000 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(tons)	(- - - - -)					\$ - - - - -						- - - - -)
100	99,134	18,348	623	56	30	1,181.90	121,642	45,816	623	76	56	1,682.13
200	99,136	18,348	1,246	111	60	594.50	121,646	45,816	1,246	152	112	844.86
300	99,139	18,348	1,868	167	90	398.71	121,650	45,816	1,868	228	169	565.77
400	99,141	18,348	2,491	222	120	300.81	121,654	45,816	2,491	304	225	426.23
500	99,144	18,348	3,114	278	151	242.07	121,659	45,816	3,114	379	281	342.50
600	99,147	18,348	3,737	333	181	202.91	121,663	45,816	3,737	455	337	286.68
700	99,149	18,348	4,359	389	211	174.94	121,667	45,816	4,359	531	393	246.81
800	99,152	18,348	4,982	444	241	153.96	121,672	45,816	4,982	607	450	216.91
900	99,154	18,348	5,605	500	271	137.64	121,676	45,816	5,605	683	506	193.65
1,000	99,157	18,348	6,228	555	301	124.59	121,680	45,816	6,228	759	562	175.05
1,100	99,159	18,348	6,851	611	331	113.91	121,684	45,816	6,851	835	618	159.82
1,200	99,162	18,348	7,473	666	361	105.01	121,689	45,816	7,473	910	674	147.14
1,300	99,165	18,348	8,096	722	391	97.48	121,693	45,816	8,096	986	731	136.40
1,400	99,167	18,348	8,719	778	421	91.02	121,697	45,816	8,719	1,062	787	127.20
1,500	99,170	18,348	9,342	833	452	85.43	121,702	45,816	9,342	1,138	843	119.23
1,600	99,172	18,348	9,964	889	482	80.53	121,706	45,816	9,964	1,214	899	112.25
1,700	99,175	18,348	10,587	944	512	76.22	121,710	45,816	10,587	1,290	955	106.09
1,800	99,177	18,348	11,210	1,000	542	72.38	121,715	45,816	11,210	1,366	1,012	100.62
1,900	99,180	18,348	11,833	1,055	572	68.94	121,719	45,816	11,833	1,442	1,068	95.72
2,000	99,183	18,348	12,456	1,111	602	65.85	121,723	45,816	12,456	1,517	1,124	91.32
2,100	99,185	18,348	13,078	1,166	632	63.05	121,727	45,816	13,078	1,593	1,180	87.33
2,200	99,188	18,348	13,701	1,222	662	60.51	121,732	45,816	13,701	1,669	1,237	83.71
2,300	99,190	18,348	14,324	1,277	692	58.19	121,736	45,816	14,324	1,745	1,293	80.40
2,400	99,193	18,348	14,947	1,333	722	56.06	121,740	45,816	14,947	1,821	1,349	77.36
2,500	99,195	18,348	15,570	1,388	753	54.10	121,745	45,816	15,570	1,897	1,405	74.57
2,600	99,198	18,348	16,192	1,444	783	52.29	121,749	45,816	16,192	1,973	1,461	72.00
2,700	99,201	18,348	16,815	1,499	813	50.62	121,753	45,816	16,815	2,048	1,518	69.61
2,800	99,203	18,348	17,438	1,555	843	49.07	121,757	45,816	17,438	2,124	1,574	67.40
2,900	99,206	18,348	18,061	1,611	873	47.62	121,762	45,816	18,061	2,200	1,630	65.33
3,000	99,208	18,348	18,683	1,666	903	46.27	121,766	45,816	18,683	2,276	1,686	63.41
3,100	99,211	18,348	19,306	1,722	933	45.01	121,770	45,816	19,306	2,352	1,742	61.61
3,200	99,214	18,348	19,929	1,777	963	43.82	121,775	45,816	19,929	2,428	1,799	59.92
3,300	99,216	18,348	20,552	1,833	993	42.71	121,779	45,816	20,552	2,504	1,855	58.33
3,400	99,219	18,348	21,175	1,888	1,024	41.66	121,783	45,816	21,175	2,580	1,911	56.84
3,500	99,221	18,348	21,797	1,944	1,054	40.68	121,787	45,816	21,797	2,655	1,967	55.44
3,600	99,224	18,348	22,420	1,999	1,084	39.74	121,792	45,816	22,420	2,731	2,023	54.11
3,700	99,226	18,348	23,043	2,055	1,114	38.86	121,796	45,816	23,043	2,807	2,080	52.85
3,800	99,229	18,348	23,666	2,110	1,144	38.03	121,800	45,816	23,666	2,883	2,136	51.66
3,900	99,232	18,348	24,288	2,166	1,174	37.23	121,805	45,816	24,288	2,959	2,192	50.53
4,000	99,234	18,348	24,911	2,221	1,204	36.48	121,809	45,816	24,911	3,035	2,248	49.45
5,000	99,260	18,348	31,139	2,777	1,505	30.61	121,852	45,816	31,139	3,793	2,810	41.08
6,000	99,286	18,348	37,367	3,332	1,806	26.69	121,895	45,816	37,367	4,552	3,372	35.50
7,000	99,311	18,348	43,595	3,888	2,107	23.89	121,938	45,816	43,595	5,311	3,934	31.51
8,000	99,337	18,348	49,822	4,443	2,408	21.79	121,981	45,816	49,822	6,069	4,496	28.52
9,000	99,363	18,348	56,050	4,998	2,709	20.16	122,024	45,816	56,050	6,828	5,059	26.20
10,000	99,389	18,348	62,278	5,554	3,010	18.86	122,067	45,816	62,278	7,587	5,621	24.34
11,000	99,414	18,348	68,506	6,109	3,311	17.79	122,109	45,816	68,506	8,345	6,183	22.81
12,000	99,440	18,348	74,734	6,664	3,612	16.90	122,152	45,816	74,734	9,104	6,745	21.55
13,000	99,466	18,348	80,961	7,220	3,913	16.15	122,195	45,816	80,961	9,863	7,307	20.47
14,000	99,492	18,348	87,189	7,775	4,215	15.50	122,238	45,816	87,189	10,621	7,869	19.55
15,000	99,517	18,348	93,417	8,330	4,516	14.94	122,281	45,816	93,417	11,380	8,431	18.76

cont'd.

Appendix Table 7. (cont'd.)

Annual sales	2,000 ton tower facility						4,000 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(tons)	(-)	(-)	(-)	(-)	(-)	\$	(-)	(-)	(-)	(-)	(-)	(-)
100	129,393	45,816	623	76	56	1,759.64	189,689	92,206	621	73	50	2,826.39
200	129,397	45,816	1,245	152	112	883.61	189,695	92,206	1,242	147	99	1,416.95
300	129,401	45,816	1,868	228	169	591.61	189,701	92,206	1,864	220	149	947.13
400	129,405	45,816	2,491	304	225	445.60	189,707	92,206	2,485	293	199	712.22
500	129,410	45,816	3,113	379	281	358.00	189,713	92,206	3,106	367	249	571.28
600	129,414	45,816	3,736	455	337	299.60	189,719	92,206	3,727	440	298	477.32
700	129,418	45,816	4,359	531	393	257.88	189,725	92,206	4,349	513	348	410.20
800	129,423	45,816	4,981	607	450	226.60	189,731	92,206	4,970	587	398	359.86
900	129,427	45,816	5,604	683	506	202.26	189,737	92,206	5,591	660	448	320.71
1,000	129,431	45,816	6,226	759	562	182.79	189,743	92,206	6,212	733	497	289.39
1,100	129,435	45,816	6,849	835	618	166.87	189,749	92,206	6,834	807	547	263.77
1,200	129,440	45,816	7,472	910	674	153.59	189,755	92,206	7,455	880	597	242.41
1,300	129,444	45,816	8,094	986	731	142.36	189,761	92,206	8,076	953	647	224.34
1,400	129,448	45,816	8,717	1,062	787	132.74	189,767	92,206	8,697	1,026	696	208.85
1,500	129,453	45,816	9,340	1,138	843	124.39	189,773	92,206	9,319	1,100	746	195.43
1,600	129,457	45,816	9,962	1,214	899	117.09	189,779	92,206	9,940	1,173	796	183.68
1,700	129,461	45,816	10,585	1,290	955	110.65	189,785	92,206	10,561	1,246	846	173.32
1,800	129,466	45,816	11,208	1,366	1,012	104.93	189,791	92,206	11,182	1,320	895	164.11
1,900	129,470	45,816	11,830	1,442	1,068	99.80	189,797	92,206	11,804	1,393	945	155.87
2,000	129,474	45,816	12,453	1,517	1,124	95.19	189,803	92,206	12,425	1,466	995	148.45
2,100	129,478	45,816	13,076	1,593	1,180	91.02	189,809	92,206	13,046	1,540	1,045	141.74
2,200	129,483	45,816	13,698	1,669	1,237	87.23	189,815	92,206	13,667	1,613	1,094	135.63
2,300	129,487	45,816	14,321	1,745	1,293	83.77	189,821	92,206	14,289	1,686	1,144	130.06
2,400	129,491	45,816	14,943	1,821	1,349	80.59	189,827	92,206	14,910	1,760	1,194	124.96
2,500	129,496	45,816	15,566	1,897	1,405	77.67	189,833	92,206	15,531	1,833	1,244	120.26
2,600	129,500	45,816	16,189	1,973	1,461	74.98	189,839	92,206	16,152	1,906	1,293	115.92
2,700	129,504	45,816	16,811	2,048	1,518	72.48	189,845	92,206	16,774	1,979	1,343	111.91
2,800	129,508	45,816	17,434	2,124	1,574	70.16	189,851	92,206	17,395	2,053	1,393	108.18
2,900	129,513	45,816	18,057	2,200	1,630	68.01	189,857	92,206	18,016	2,126	1,443	104.71
3,000	129,517	45,816	18,679	2,276	1,686	65.99	189,863	92,206	18,637	2,199	1,492	101.47
3,100	129,521	45,816	19,302	2,352	1,742	64.11	189,869	92,206	19,258	2,273	1,542	98.43
3,200	129,526	45,816	19,925	2,428	1,799	62.34	189,875	92,206	19,880	2,346	1,592	95.59
3,300	129,530	45,816	20,547	2,504	1,855	60.68	189,881	92,206	20,501	2,419	1,642	92.92
3,400	129,534	45,816	21,170	2,580	1,911	59.12	189,887	92,206	21,122	2,493	1,691	90.41
3,500	129,538	45,816	21,793	2,655	1,967	57.65	189,893	92,206	21,743	2,566	1,741	88.04
3,600	129,543	45,816	22,415	2,731	2,023	56.26	189,899	92,206	22,365	2,639	1,791	85.81
3,700	129,547	45,816	23,038	2,807	2,080	54.94	189,905	92,206	22,986	2,713	1,841	83.69
3,800	129,551	45,816	23,661	2,883	2,136	53.70	189,911	92,206	23,607	2,786	1,890	81.68
3,900	129,556	45,816	24,283	2,959	2,192	52.51	189,917	92,206	24,228	2,859	1,940	79.78
4,000	129,560	45,816	24,906	3,035	2,248	51.39	189,923	92,206	24,850	2,933	1,990	77.98
5,000	129,603	45,816	31,132	3,793	2,810	42.63	189,983	92,206	31,062	3,666	2,487	63.88
6,000	129,646	45,816	37,359	4,552	3,372	36.79	190,043	92,206	37,274	4,399	2,985	54.48
7,000	129,689	45,816	43,585	5,311	3,934	32.62	190,103	92,206	43,487	5,132	3,482	47.77
8,000	129,732	45,816	49,812	6,069	4,496	29.49	190,163	92,206	49,699	5,865	3,980	42.74
9,000	129,775	45,816	56,038	6,828	5,059	27.06	190,223	92,206	55,912	6,598	4,477	38.82
10,000	129,818	45,816	62,265	7,587	5,621	25.11	190,284	92,206	62,124	7,331	4,975	35.69
11,000	129,860	45,816	68,491	8,345	6,183	23.52	190,344	92,206	68,337	8,064	5,472	33.13
12,000	129,903	45,816	74,717	9,104	6,745	22.19	190,404	92,206	74,549	8,797	5,970	30.99
13,000	129,946	45,816	80,944	9,863	7,307	21.07	190,464	92,206	80,761	9,531	6,467	29.19
14,000	129,989	45,816	87,170	10,621	7,869	20.10	190,524	92,206	86,974	10,264	6,965	27.64
15,000	130,032	45,816	93,397	11,380	8,431	19.27	190,584	92,206	93,186	10,997	7,462	26.30

* Costs not reported when sales exceed equipment capacity.

** Changes in fixed costs reflect assumed positive relationship between facility land values and sales density.

Appendix Table 8. Fixed and variable costs related to volume and radius of sales area for specified sizes of dry fertilizer custom application for a 20 mile radius sales area, western North Dakota, 1992.

Annual sales (tons)	500 ton facility						800 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
	(-	-	-	-	-	\$	-	-	-	-	-	-
100	42,607	13,890	623	55	47	572.22	45,549	18,348	623	55	47	646.22
200	42,607	13,890	1,247	110	93	289.74	45,550	18,348	1,247	110	93	326.74
300	42,607	13,890	1,870	165	140	195.58	45,551	18,348	1,870	165	140	220.25
400	42,608	13,890	2,493	220	187	148.50	45,551	18,348	2,493	220	187	167.00
500	42,608	13,890	3,117	275	234	120.25	45,552	18,348	3,117	275	234	135.05
600	42,608	13,890	3,740	330	280	101.42	45,553	18,348	3,740	330	280	113.75
700	42,609	13,890	4,364	385	327	87.96	45,553	18,348	4,364	385	327	98.54
800	42,609	13,890	4,987	440	374	77.88	45,554	18,348	4,987	440	374	87.13
900	42,609	13,890	5,610	495	421	70.03	45,555	18,348	5,610	495	421	78.25
1,000	42,610	13,890	6,234	550	467	63.75	45,555	18,348	6,234	550	467	71.15
1,100	42,610	13,890	6,857	605	514	58.61	45,556	18,348	6,857	605	514	65.35
1,200	42,610	13,890	7,480	660	561	54.33	45,557	18,348	7,480	660	561	60.50
1,300	42,611	13,890	8,104	715	607	50.71	45,557	18,348	8,104	715	607	56.41
1,400	42,611	13,890	8,727	770	654	47.61	45,558	18,348	8,727	770	654	52.90
1,500	42,611	13,890	9,351	825	701	44.92	45,559	18,348	9,351	825	701	49.86
1,600	42,612	13,890	9,974	880	748	42.56	45,559	18,348	9,974	880	748	47.19
1,700	42,612	13,890	10,597	935	794	40.49	45,560	18,348	10,597	935	794	44.84
1,800	42,612	13,890	11,221	990	841	38.64	45,561	18,348	11,221	990	841	42.76
1,900	42,613	13,890	11,844	1,045	888	36.99	45,561	18,348	11,844	1,045	888	40.89
2,000	42,613	13,890	12,467	1,100	935	35.50	45,562	18,348	12,467	1,100	935	39.21
2,100	42,613	13,890	13,091	1,155	981	34.16	45,563	18,348	13,091	1,155	981	37.68
2,200	42,614	13,890	13,714	1,210	1,028	32.93	45,563	18,348	13,714	1,210	1,028	36.30
2,300	42,614	13,890	14,338	1,265	1,075	31.82	45,564	18,348	14,338	1,265	1,075	35.04
2,400	42,614	13,890	14,961	1,320	1,121	30.79	45,565	18,348	14,961	1,320	1,121	33.88
2,500	42,615	13,890	15,584	1,375	1,168	29.85	45,565	18,348	15,584	1,375	1,168	32.82
2,600	42,615	13,890	16,208	1,430	1,215	28.98	45,566	18,348	16,208	1,430	1,215	31.83
2,700	42,615	13,890	16,831	1,485	1,262	28.18	45,567	18,348	16,831	1,485	1,262	30.92
2,800	42,616	13,890	17,454	1,540	1,308	27.43	45,567	18,348	17,454	1,540	1,308	30.08
2,900	42,616	13,890	18,078	1,595	1,355	26.74	45,568	18,348	18,078	1,595	1,355	29.29
3,000	42,616	13,890	18,701	1,650	1,402	26.09	45,569	18,348	18,701	1,650	1,402	28.56
3,100	42,617	13,890	19,325	1,705	1,449	25.48	45,569	18,348	19,325	1,705	1,449	27.87
3,200	42,617	13,890	19,948	1,760	1,495	24.91	45,570	18,348	19,948	1,760	1,495	27.23
3,300	42,617	13,890	20,571	1,815	1,542	24.37	45,571	18,348	20,571	1,815	1,542	26.62
3,400	42,618	13,890	21,195	1,870	1,589	23.87	45,571	18,348	21,195	1,870	1,589	26.05
3,500	42,618	13,890	21,818	1,925	1,635	23.40	45,572	18,348	21,818	1,925	1,635	25.51
3,600	42,618	13,890	22,441	1,980	1,682	22.95	45,573	18,348	22,441	1,980	1,682	25.01
3,700	42,619	13,890	23,065	2,035	1,729	22.52	45,573	18,348	23,065	2,035	1,729	24.53
3,800	42,619	13,890	23,688	2,090	1,776	22.12	45,574	18,348	23,688	2,090	1,776	24.07
3,900	42,619	13,890	24,312	2,145	1,822	21.74	45,575	18,348	24,312	2,145	1,822	23.64
4,000	42,620	13,890	24,935	2,200	1,869	21.38	45,575	18,348	24,935	2,200	1,869	23.23
5,000	42,623	13,890	31,169	2,750	2,336	18.55	45,582	18,348	31,169	2,750	2,336	20.04
6,000	42,626	13,890	37,402	3,300	2,804	16.67	45,589	18,348	37,402	3,300	2,804	17.91
7,000	42,630	13,890	43,636	3,850	3,271	15.33	45,596	18,348	43,636	3,850	3,271	16.39
8,000	42,633	13,890	49,870	4,400	3,738	14.32	45,602	18,348	49,870	4,400	3,738	15.24
9,000	42,636	13,890	56,104	4,950	4,206	13.53	45,609	18,348	56,104	4,950	4,206	14.36
10,000	42,640	13,890	62,337	5,500	4,673	12.90	45,616	18,348	62,337	5,500	4,673	13.65
11,000	42,643	13,890	68,571	6,050	5,140	12.39	45,622	18,348	68,571	6,050	5,140	13.07
12,000	42,646	13,890	74,805	6,600	5,607	11.96	45,629	18,348	74,805	6,600	5,607	12.58
13,000	42,650	13,890	81,039	7,150	6,075	11.60	45,636	18,348	81,039	7,150	6,075	12.17
14,000	42,653	13,890	87,272	7,700	6,542	11.29	45,643	18,348	87,272	7,700	6,542	11.82
15,000	42,656	13,890	93,506	8,250	7,009	11.02	45,649	18,348	93,506	8,250	7,009	11.52

cont'd.

Appendix Table 8. (cont'd.)

Annual sales	1,300 ton facility						2,000 ton facility					
	Fixed costs		Variable costs related to:			Total/ton	Fixed costs		Variable costs related to:			Total/ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(tons)	(- - - - -)	(- - - - -)	(- - - - -)	(- - - - -)	(- - - - -)	\$ - - - - -	(- - - - -)	(- - - - -)	(- - - - -)	(- - - - -)	(- - - - -)	(- - - - -)
100	99,132	18,348	623	55	47	1,182.04	121,639	45,816	623	74	85	1,682.37
200	99,133	18,348	1,246	110	93	594.65	121,641	45,816	1,246	149	169	845.10
300	99,134	18,348	1,868	165	140	398.85	121,642	45,816	1,868	223	254	566.01
400	99,135	18,348	2,491	220	187	300.95	121,644	45,816	2,491	297	339	426.47
500	99,136	18,348	3,114	275	234	242.21	121,646	45,816	3,114	372	423	342.74
600	99,137	18,348	3,737	330	280	203.05	121,647	45,816	3,737	446	508	286.92
700	99,138	18,348	4,359	385	327	175.08	121,649	45,816	4,359	520	592	247.05
800	99,139	18,348	4,982	440	374	154.10	121,651	45,816	4,982	595	677	217.15
900	99,140	18,348	5,605	495	421	137.79	121,652	45,816	5,605	669	762	193.89
1,000	99,141	18,348	6,228	550	467	124.73	121,654	45,816	6,228	743	846	175.29
1,100	99,142	18,348	6,851	605	514	114.05	121,656	45,816	6,851	818	931	160.06
1,200	99,143	18,348	7,473	660	561	105.15	121,657	45,816	7,473	892	1,016	147.38
1,300	99,144	18,348	8,096	715	607	97.62	121,659	45,816	8,096	966	1,100	136.64
1,400	99,145	18,348	8,719	770	654	91.17	121,661	45,816	8,719	1,041	1,185	127.44
1,500	99,146	18,348	9,342	825	701	85.57	121,662	45,816	9,342	1,115	1,270	119.47
1,600	99,147	18,348	9,964	880	748	80.68	121,664	45,816	9,964	1,189	1,354	112.49
1,700	99,148	18,348	10,587	935	794	76.36	121,666	45,816	10,587	1,264	1,439	106.34
1,800	99,149	18,348	11,210	990	841	72.52	121,667	45,816	11,210	1,338	1,523	100.86
1,900	99,150	18,348	11,833	1,045	888	69.09	121,669	45,816	11,833	1,412	1,608	95.97
2,000	99,151	18,348	12,456	1,100	935	65.99	121,671	45,816	12,456	1,487	1,693	91.56
2,100	99,152	18,348	13,078	1,155	981	63.20	121,672	45,816	13,078	1,561	1,777	87.57
2,200	99,153	18,348	13,701	1,210	1,028	60.65	121,674	45,816	13,701	1,635	1,862	83.95
2,300	99,154	18,348	14,324	1,265	1,075	58.33	121,676	45,816	14,324	1,710	1,947	80.64
2,400	99,155	18,348	14,947	1,320	1,121	56.20	121,677	45,816	14,947	1,784	2,031	77.61
2,500	99,156	18,348	15,570	1,375	1,168	54.25	121,679	45,816	15,570	1,858	2,116	74.82
2,600	99,157	18,348	16,192	1,430	1,215	52.44	121,681	45,816	16,192	1,933	2,201	72.24
2,700	99,158	18,348	16,815	1,485	1,262	50.77	121,683	45,816	16,815	2,007	2,285	69.85
2,800	99,159	18,348	17,438	1,540	1,308	49.21	121,684	45,816	17,438	2,081	2,370	67.64
2,900	99,160	18,348	18,061	1,595	1,355	47.77	121,686	45,816	18,061	2,156	2,454	65.58
3,000	99,161	18,348	18,683	1,650	1,402	46.41	121,688	45,816	18,683	2,230	2,539	63.65
3,100	99,162	18,348	19,306	1,705	1,449	45.15	121,689	45,816	19,306	2,304	2,624	61.85
3,200	99,163	18,348	19,929	1,760	1,495	43.97	121,691	45,816	19,929	2,379	2,708	60.16
3,300	99,164	18,348	20,552	1,815	1,542	42.85	121,693	45,816	20,552	2,453	2,793	58.58
3,400	99,165	18,348	21,175	1,870	1,589	41.81	121,694	45,816	21,175	2,527	2,878	57.09
3,500	99,166	18,348	21,797	1,925	1,635	40.82	121,696	45,816	21,797	2,602	2,962	55.68
3,600	99,167	18,348	22,420	1,980	1,682	39.89	121,698	45,816	22,420	2,676	3,047	54.35
3,700	99,168	18,348	23,043	2,035	1,729	39.01	121,699	45,816	23,043	2,750	3,132	53.09
3,800	99,169	18,348	23,666	2,090	1,776	38.17	121,701	45,816	23,666	2,825	3,216	51.90
3,900	99,170	18,348	24,288	2,145	1,822	37.38	121,703	45,816	24,288	2,899	3,301	50.77
4,000	99,171	18,348	24,911	2,200	1,869	36.62	121,704	45,816	24,911	2,973	3,385	49.70
5,000	99,181	18,348	31,139	2,750	2,336	30.75	121,721	45,816	31,139	3,717	4,232	41.33
6,000	99,191	18,348	37,367	3,300	2,804	26.83	121,738	45,816	37,367	4,460	5,078	35.74
7,000	99,202	18,348	43,595	3,850	3,271	24.04	121,755	45,816	43,595	5,203	5,924	31.76
8,000	99,212	18,348	49,822	4,400	3,738	21.94	121,771	45,816	49,822	5,947	6,771	28.77
9,000	99,222	18,348	56,050	4,950	4,206	20.31	121,788	45,816	56,050	6,690	7,617	26.44
10,000	99,232	18,348	62,278	5,500	4,673	19.00	121,805	45,816	62,278	7,434	8,464	24.58
11,000	99,242	18,348	68,506	6,050	5,140	17.94	121,822	45,816	68,506	8,177	9,310	23.06
12,000	99,252	18,348	74,734	6,600	5,607	17.05	121,838	45,816	74,734	8,920	10,156	21.79
13,000	99,262	18,348	80,961	7,150	6,075	16.29	121,855	45,816	80,961	9,664	11,003	20.72
14,000	99,272	18,348	87,189	7,700	6,542	15.65	121,872	45,816	87,189	10,407	11,849	19.80
15,000	99,282	18,348	93,417	8,250	7,009	15.09	121,889	45,816	93,417	11,150	12,695	19.00

cont'd.

Appendix Table 8. (cont'd.)

Annual sales	2,000 ton tower facility						4,000 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(tons)	(-)	(-)	(-)	(-)	(-)	\$	(-)	(-)	(-)	(-)	(-)	(-)
100	129,390	45,816	623	74	85	1,759.88	189,685	92,206	621	73	74	2,826.59
200	129,392	45,816	1,245	149	169	883.86	189,687	92,206	1,242	145	149	1,417.15
300	129,393	45,816	1,868	223	254	591.85	189,690	92,206	1,864	218	223	947.33
400	129,395	45,816	2,491	297	339	445.84	189,692	92,206	2,485	290	297	712.43
500	129,397	45,816	3,113	372	423	358.24	189,694	92,206	3,106	363	371	571.48
600	129,398	45,816	3,736	446	508	299.84	189,697	92,206	3,727	435	446	477.52
700	129,400	45,816	4,359	520	592	258.13	189,699	92,206	4,349	508	520	410.40
800	129,402	45,816	4,981	595	677	226.84	189,701	92,206	4,970	580	594	360.06
900	129,403	45,816	5,604	669	762	202.50	189,704	92,206	5,591	653	668	320.91
1,000	129,405	45,816	6,226	743	846	183.04	189,706	92,206	6,212	725	743	289.59
1,100	129,407	45,816	6,849	818	931	167.11	189,708	92,206	6,834	798	817	263.97
1,200	129,408	45,816	7,472	892	1,016	153.84	189,711	92,206	7,455	870	891	242.61
1,300	129,410	45,816	8,094	966	1,100	142.61	189,713	92,206	8,076	943	965	224.54
1,400	129,412	45,816	8,717	1,041	1,185	132.98	189,715	92,206	8,697	1,015	1,040	209.05
1,500	129,413	45,816	9,340	1,115	1,270	124.64	189,718	92,206	9,319	1,088	1,114	195.63
1,600	129,415	45,816	9,962	1,189	1,354	117.34	189,720	92,206	9,940	1,160	1,188	183.88
1,700	129,417	45,816	10,585	1,264	1,439	110.89	189,722	92,206	10,561	1,233	1,263	173.52
1,800	129,418	45,816	11,208	1,338	1,523	105.17	189,725	92,206	11,182	1,305	1,337	164.31
1,900	129,420	45,816	11,830	1,412	1,608	100.05	189,727	92,206	11,804	1,378	1,411	156.07
2,000	129,422	45,816	12,453	1,487	1,693	95.44	189,730	92,206	12,425	1,450	1,485	148.65
2,100	129,423	45,816	13,076	1,561	1,777	91.26	189,732	92,206	13,046	1,523	1,560	141.94
2,200	129,425	45,816	13,698	1,635	1,862	87.47	189,734	92,206	13,667	1,595	1,634	135.83
2,300	129,427	45,816	14,321	1,710	1,947	84.01	189,737	92,206	14,289	1,668	1,708	130.26
2,400	129,428	45,816	14,943	1,784	2,031	80.83	189,739	92,206	14,910	1,740	1,782	125.16
2,500	129,430	45,816	15,566	1,858	2,116	77.91	189,741	92,206	15,531	1,813	1,857	120.46
2,600	129,432	45,816	16,189	1,933	2,201	75.22	189,744	92,206	16,152	1,885	1,931	116.12
2,700	129,434	45,816	16,811	2,007	2,285	72.72	189,746	92,206	16,774	1,958	2,005	112.11
2,800	129,435	45,816	17,434	2,081	2,370	70.41	189,748	92,206	17,395	2,030	2,079	108.38
2,900	129,437	45,816	18,057	2,156	2,454	68.25	189,751	92,206	18,016	2,103	2,154	104.91
3,000	129,439	45,816	18,679	2,230	2,539	66.23	189,753	92,206	18,637	2,175	2,228	101.67
3,100	129,440	45,816	19,302	2,304	2,624	64.35	189,755	92,206	19,258	2,248	2,302	98.64
3,200	129,442	45,816	19,925	2,379	2,708	62.58	189,758	92,206	19,880	2,320	2,377	95.79
3,300	129,444	45,816	20,547	2,453	2,793	60.93	189,760	92,206	20,501	2,393	2,451	93.12
3,400	129,445	45,816	21,170	2,527	2,878	59.36	189,762	92,206	21,122	2,465	2,525	90.61
3,500	129,447	45,816	21,793	2,602	2,962	57.89	189,765	92,206	21,743	2,538	2,599	88.24
3,600	129,449	45,816	22,415	2,676	3,047	56.50	189,767	92,206	22,365	2,610	2,674	86.01
3,700	129,450	45,816	23,038	2,750	3,132	55.19	189,769	92,206	22,986	2,683	2,748	83.89
3,800	129,452	45,816	23,661	2,825	3,216	53.94	189,772	92,206	23,607	2,755	2,822	81.88
3,900	129,454	45,816	24,283	2,899	3,301	52.76	189,774	92,206	24,228	2,828	2,896	79.98
4,000	129,455	45,816	24,906	2,973	3,385	51.63	189,776	92,206	24,850	2,900	2,971	78.18
5,000	129,472	45,816	31,132	3,717	4,232	42.87	189,800	92,206	31,062	3,625	3,713	64.08
6,000	129,489	45,816	37,359	4,460	5,078	37.03	189,823	92,206	37,274	4,350	4,456	54.69
7,000	129,506	45,816	43,585	5,203	5,924	32.86	189,847	92,206	43,487	5,076	5,199	47.97
8,000	129,522	45,816	49,812	5,947	6,771	29.73	189,870	92,206	49,699	5,801	5,941	42.94
9,000	129,539	45,816	56,038	6,690	7,617	27.30	189,894	92,206	55,912	6,526	6,684	39.02
10,000	129,556	45,816	62,265	7,434	8,464	25.35	189,917	92,206	62,124	7,251	7,427	35.89
11,000	129,573	45,816	68,491	8,177	9,310	23.76	189,941	92,206	68,337	7,976	8,169	33.33
12,000	129,589	45,816	74,717	8,920	10,156	22.43	189,964	92,206	74,549	8,701	8,912	31.19
13,000	129,606	45,816	80,944	9,664	11,003	21.31	189,988	92,206	80,761	9,426	9,655	29.39
14,000	129,623	45,816	87,170	10,407	11,849	20.35	190,011	92,206	86,974	10,151	10,397	27.84
15,000	129,640	45,816	93,397	11,150	12,695	19.51	190,035	92,206	93,186	10,876	11,140	26.50

* Costs not reported when sales exceed equipment capacity.

** Changes in fixed costs reflect assumed positive relationship between facility land values and sales density.

Appendix Table 9. Fixed and variable costs related to volume and radius of sales area for specified sizes of dry fertilizer custom application for a 35 mile radius sales area, western North Dakota, 1992.

Annual sales	500 ton facility						800 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(tons)	(-	-	-	-	-	-	\$	-	-	-	-	-
100	42,606	13,890	623	56	80	572.56	45,549	18,348	623	56	80	646.56
200	42,606	13,890	1,247	112	160	290.08	45,549	18,348	1,247	112	160	327.08
300	42,607	13,890	1,870	168	240	195.92	45,549	18,348	1,870	168	240	220.58
400	42,607	13,890	2,493	224	320	148.84	45,550	18,348	2,493	224	320	167.34
500	42,607	13,890	3,117	280	400	120.59	45,550	18,348	3,117	280	400	135.39
600	42,607	13,890	3,740	336	480	101.76	45,550	18,348	3,740	336	480	114.09
700	42,607	13,890	4,364	392	560	88.30	45,550	18,348	4,364	392	560	98.88
800	42,607	13,890	4,987	448	640	78.22	45,550	18,348	4,987	448	640	87.47
900	42,607	13,890	5,610	504	720	70.37	45,551	18,348	5,610	504	720	78.59
1,000	42,607	13,890	6,234	560	800	64.09	45,551	18,348	6,234	560	800	71.49
1,100	42,607	13,890	6,857	616	880	58.96	45,551	18,348	6,857	616	880	65.68
1,200	42,608	13,890	7,480	672	960	54.68	45,551	18,348	7,480	672	960	60.84
1,300	42,608	13,890	8,104	728	1,040	51.05	45,552	18,348	8,104	728	1,040	56.75
1,400	42,608	13,890	8,727	784	1,120	47.95	45,552	18,348	8,727	784	1,120	53.24
1,500	42,608	13,890	9,351	840	1,200	45.26	45,552	18,348	9,351	840	1,200	50.19
1,600	42,608	13,890	9,974	896	1,280	42.90	45,552	18,348	9,974	896	1,280	47.53
1,700	42,608	13,890	10,597	952	1,360	40.83	45,552	18,348	10,597	952	1,360	45.18
1,800	42,608	13,890	11,221	1,008	1,440	38.98	45,553	18,348	11,221	1,008	1,440	43.09
1,900	42,608	13,890	11,844	1,064	1,520	37.33	45,553	18,348	11,844	1,064	1,520	41.23
2,000	42,608	13,890	12,467	1,120	1,600	35.84	45,553	18,348	12,467	1,120	1,600	39.54
2,100	42,608	13,890	13,091	1,176	1,680	34.50	45,553	18,348	13,091	1,176	1,680	38.02
2,200	42,609	13,890	13,714	1,232	1,760	33.27	45,553	18,348	13,714	1,232	1,760	36.64
2,300	42,609	13,890	14,338	1,288	1,839	32.16	45,554	18,348	14,338	1,288	1,839	35.38
2,400	42,609	13,890	14,961	1,344	1,919	31.13	45,554	18,348	14,961	1,344	1,919	34.22
2,500	42,609	13,890	15,584	1,400	1,999	30.19	45,554	18,348	15,584	1,400	1,999	33.15
2,600	42,609	13,890	16,208	1,456	2,079	29.32	45,554	18,348	16,208	1,456	2,079	32.17
2,700	42,609	13,890	16,831	1,512	2,159	28.52	45,555	18,348	16,831	1,512	2,159	31.26
2,800	42,609	13,890	17,454	1,568	2,239	27.77	45,555	18,348	17,454	1,568	2,239	30.42
2,900	42,609	13,890	18,078	1,624	2,319	27.08	45,555	18,348	18,078	1,624	2,319	29.63
3,000	42,609	13,890	18,701	1,680	2,399	26.43	45,555	18,348	18,701	1,680	2,399	28.89
3,100	42,610	13,890	19,325	1,736	2,479	25.82	45,555	18,348	19,325	1,736	2,479	28.21
3,200	42,610	13,890	19,948	1,792	2,559	25.25	45,556	18,348	19,948	1,792	2,559	27.56
3,300	42,610	13,890	20,571	1,848	2,639	24.71	45,556	18,348	20,571	1,848	2,639	26.96
3,400	42,610	13,890	21,195	1,904	2,719	24.21	45,556	18,348	21,195	1,904	2,719	26.39
3,500	42,610	13,890	21,818	1,960	2,799	23.74	45,556	18,348	21,818	1,960	2,799	25.85
3,600	42,610	13,890	22,441	2,016	2,879	23.29	45,557	18,348	22,441	2,016	2,879	25.34
3,700	42,610	13,890	23,065	2,072	2,959	22.86	45,557	18,348	23,065	2,072	2,959	24.86
3,800	42,610	13,890	23,688	2,128	3,039	22.46	45,557	18,348	23,688	2,128	3,039	24.41
3,900	42,610	13,890	24,312	2,184	3,119	22.08	45,557	18,348	24,312	2,184	3,119	23.98
4,000	42,611	13,890	24,935	2,240	3,199	21.72	45,557	18,348	24,935	2,240	3,199	23.57
5,000	42,612	13,890	31,169	2,800	3,999	18.89	45,560	18,348	31,169	2,800	3,999	20.37
6,000	42,613	13,890	37,402	3,360	4,799	17.01	45,562	18,348	37,402	3,360	4,799	18.25
7,000	42,614	13,890	43,636	3,920	5,598	15.67	45,564	18,348	43,636	3,920	5,598	16.72
8,000	42,615	13,890	49,870	4,480	6,398	14.66	45,566	18,348	49,870	4,480	6,398	15.58
9,000	42,616	13,890	56,104	5,040	7,198	13.87	45,568	18,348	56,104	5,040	7,198	14.70
10,000	42,617	13,890	62,337	5,600	7,998	13.24	45,571	18,348	62,337	5,600	7,998	13.99
11,000	42,618	13,890	68,571	6,160	8,798	12.73	45,573	18,348	68,571	6,160	8,798	13.40
12,000	42,619	13,890	74,805	6,720	9,597	12.30	45,575	18,348	74,805	6,720	9,597	12.92
13,000	42,620	13,890	81,039	7,280	10,397	11.94	45,577	18,348	81,039	7,280	10,397	12.51

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Appendix Table 9. (cont'd.)

Annual sales	1,300 ton facility						2,000 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(tons)	(-	-	-	-	-	\$	-	-	-	-	-	-)
100	99,131	18,348	623	56	80	1,182.38	121,638	45,816	623	74	141	1,682.93
200	99,132	18,348	1,246	112	160	594.98	121,638	45,816	1,246	149	283	845.66
300	99,132	18,348	1,868	168	240	399.19	121,639	45,816	1,868	223	424	566.57
400	99,132	18,348	2,491	224	320	301.29	121,639	45,816	2,491	297	566	427.03
500	99,133	18,348	3,114	280	400	242.55	121,640	45,816	3,114	372	707	343.30
600	99,133	18,348	3,737	336	480	203.39	121,641	45,816	3,737	446	849	287.48
700	99,133	18,348	4,359	392	560	175.42	121,641	45,816	4,359	520	990	247.61
800	99,134	18,348	4,982	448	640	154.44	121,642	45,816	4,982	594	1,132	217.71
900	99,134	18,348	5,605	504	720	138.12	121,642	45,816	5,605	669	1,273	194.45
1,000	99,134	18,348	6,228	560	800	125.07	121,643	45,816	6,228	743	1,415	175.84
1,100	99,135	18,348	6,851	616	880	114.39	121,643	45,816	6,851	817	1,556	160.62
1,200	99,135	18,348	7,473	672	960	105.49	121,644	45,816	7,473	892	1,698	147.94
1,300	99,135	18,348	8,096	728	1,040	97.96	121,644	45,816	8,096	966	1,839	137.20
1,400	99,136	18,348	8,719	784	1,120	91.50	121,645	45,816	8,719	1,040	1,981	128.00
1,500	99,136	18,348	9,342	840	1,200	85.91	121,645	45,816	9,342	1,114	2,122	120.03
1,600	99,136	18,348	9,964	896	1,280	81.02	121,646	45,816	9,964	1,189	2,264	113.05
1,700	99,137	18,348	10,587	952	1,360	76.70	121,647	45,816	10,587	1,263	2,405	106.89
1,800	99,137	18,348	11,210	1,008	1,440	72.86	121,647	45,816	11,210	1,337	2,547	101.42
1,900	99,137	18,348	11,833	1,064	1,520	69.42	121,648	45,816	11,833	1,412	2,688	96.52
2,000	99,138	18,348	12,456	1,120	1,600	66.33	121,648	45,816	12,456	1,486	2,830	92.12
2,100	99,138	18,348	13,078	1,176	1,680	63.53	121,649	45,816	13,078	1,560	2,971	88.13
2,200	99,138	18,348	13,701	1,232	1,760	60.99	121,649	45,816	13,701	1,635	3,113	84.51
2,300	99,139	18,348	14,324	1,288	1,839	58.67	121,650	45,816	14,324	1,709	3,254	81.20
2,400	99,139	18,348	14,947	1,344	1,919	56.54	121,650	45,816	14,947	1,783	3,396	78.16
2,500	99,139	18,348	15,570	1,400	1,999	54.58	121,651	45,816	15,570	1,857	3,537	75.37
2,600	99,140	18,348	16,192	1,456	2,079	52.77	121,651	45,816	16,192	1,932	3,679	72.80
2,700	99,140	18,348	16,815	1,512	2,159	51.10	121,652	45,816	16,815	2,006	3,820	70.41
2,800	99,140	18,348	17,438	1,568	2,239	49.55	121,653	45,816	17,438	2,080	3,962	68.20
2,900	99,141	18,348	18,061	1,624	2,319	48.10	121,653	45,816	18,061	2,155	4,103	66.13
3,000	99,141	18,348	18,683	1,680	2,399	46.75	121,654	45,816	18,683	2,229	4,245	64.21
3,100	99,141	18,348	19,306	1,736	2,479	45.49	121,654	45,816	19,306	2,303	4,386	62.41
3,200	99,142	18,348	19,929	1,792	2,559	44.30	121,655	45,816	19,929	2,377	4,528	60.72
3,300	99,142	18,348	20,552	1,848	2,639	43.19	121,655	45,816	20,552	2,452	4,669	59.13
3,400	99,142	18,348	21,175	1,904	2,719	42.14	121,656	45,816	21,175	2,526	4,811	57.64
3,500	99,143	18,348	21,797	1,960	2,799	41.16	121,656	45,816	21,797	2,600	4,952	56.24
3,600	99,143	18,348	22,420	2,016	2,879	40.22	121,657	45,816	22,420	2,675	5,094	54.91
3,700	99,143	18,348	23,043	2,072	2,959	39.34	121,657	45,816	23,043	2,749	5,235	53.65
3,800	99,144	18,348	23,666	2,128	3,039	38.51	121,658	45,816	23,666	2,823	5,377	52.46
3,900	99,144	18,348	24,288	2,184	3,119	37.71	121,659	45,816	24,288	2,898	5,518	51.33
4,000	99,144	18,348	24,911	2,240	3,199	36.96	121,659	45,816	24,911	2,972	5,660	50.25
5,000	99,148	18,348	31,139	2,800	3,999	31.09	121,665	45,816	31,139	3,715	7,075	41.88
6,000	99,151	18,348	37,367	3,360	4,799	27.17	121,670	45,816	37,367	4,458	8,490	36.30
7,000	99,154	18,348	43,595	3,920	5,598	24.37	121,676	45,816	43,595	5,201	9,905	32.31
8,000	99,157	18,348	49,822	4,480	6,398	22.28	121,681	45,816	49,822	5,944	11,320	29.32
9,000	99,161	18,348	56,050	5,040	7,198	20.64	121,687	45,816	56,050	6,687	12,735	27.00
10,000	99,164	18,348	62,278	5,600	7,998	19.34	121,692	45,816	62,278	7,429	14,150	25.14
11,000	99,167	18,348	68,506	6,160	8,798	18.27	121,697	45,816	68,506	8,172	15,564	23.61
12,000	99,171	18,348	74,734	6,720	9,597	17.38	121,703	45,816	74,734	8,915	16,979	22.35
13,000	99,174	18,348	80,961	7,280	10,397	16.63	121,708	45,816	80,961	9,658	18,394	21.27

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Appendix Table 9. (cont'd.)

Annual sales	2,000 ton tower facility						4,000 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(tons)	(-	-	-	-	-	\$	-	-	-	-	-)
100	129,389	45,816	623	74	141	1,760.44	189,683	92,206	621	76	123	2,827.10
200	129,389	45,816	1,245	149	283	884.41	189,684	92,206	1,242	152	247	1,417.66
300	129,390	45,816	1,868	223	424	592.41	189,685	92,206	1,864	228	370	947.84
400	129,390	45,816	2,491	297	566	446.40	189,686	92,206	2,485	305	493	712.94
500	129,391	45,816	3,113	372	707	358.80	189,686	92,206	3,106	381	616	571.99
600	129,392	45,816	3,736	446	849	300.40	189,687	92,206	3,727	457	740	478.03
700	129,392	45,816	4,359	520	990	258.68	189,688	92,206	4,349	533	863	410.91
800	129,393	45,816	4,981	594	1,132	227.40	189,689	92,206	4,970	609	986	360.58
900	129,393	45,816	5,604	669	1,273	203.06	189,689	92,206	5,591	685	1,110	321.42
1,000	129,394	45,816	6,226	743	1,415	183.59	189,690	92,206	6,212	761	1,233	290.10
1,100	129,394	45,816	6,849	817	1,556	167.67	189,691	92,206	6,834	837	1,356	264.48
1,200	129,395	45,816	7,472	892	1,698	154.39	189,692	92,206	7,455	914	1,480	243.12
1,300	129,395	45,816	8,094	966	1,839	143.16	189,693	92,206	8,076	990	1,603	225.05
1,400	129,396	45,816	8,717	1,040	1,981	133.54	189,693	92,206	8,697	1,066	1,726	209.56
1,500	129,396	45,816	9,340	1,114	2,122	125.19	189,694	92,206	9,319	1,142	1,849	196.14
1,600	129,397	45,816	9,962	1,189	2,264	117.89	189,695	92,206	9,940	1,218	1,973	184.39
1,700	129,398	45,816	10,585	1,263	2,405	111.45	189,696	92,206	10,561	1,294	2,096	174.03
1,800	129,398	45,816	11,208	1,337	2,547	105.73	189,696	92,206	11,182	1,370	2,219	164.82
1,900	129,399	45,816	11,830	1,412	2,688	100.60	189,697	92,206	11,804	1,446	2,343	156.58
2,000	129,399	45,816	12,453	1,486	2,830	95.99	189,698	92,206	12,425	1,523	2,466	149.16
2,100	129,400	45,816	13,076	1,560	2,971	91.82	189,699	92,206	13,046	1,599	2,589	142.45
2,200	129,400	45,816	13,698	1,635	3,113	88.03	189,699	92,206	13,667	1,675	2,713	136.35
2,300	129,401	45,816	14,321	1,709	3,254	84.57	189,700	92,206	14,289	1,751	2,836	130.77
2,400	129,401	45,816	14,943	1,783	3,396	81.39	189,701	92,206	14,910	1,827	2,959	125.67
2,500	129,402	45,816	15,566	1,857	3,537	78.47	189,702	92,206	15,531	1,903	3,082	120.97
2,600	129,402	45,816	16,189	1,932	3,679	75.78	189,702	92,206	16,152	1,979	3,206	116.63
2,700	129,403	45,816	16,811	2,006	3,820	73.28	189,703	92,206	16,774	2,056	3,329	112.62
2,800	129,404	45,816	17,434	2,080	3,962	70.96	189,704	92,206	17,395	2,132	3,452	108.89
2,900	129,404	45,816	18,057	2,155	4,103	68.81	189,705	92,206	18,016	2,208	3,576	105.42
3,000	129,405	45,816	18,679	2,229	4,245	66.79	189,706	92,206	18,637	2,284	3,699	102.18
3,100	129,405	45,816	19,302	2,303	4,386	64.91	189,706	92,206	19,258	2,360	3,822	99.15
3,200	129,406	45,816	19,925	2,377	4,528	63.14	189,707	92,206	19,880	2,436	3,946	96.30
3,300	129,406	45,816	20,547	2,452	4,669	61.48	189,708	92,206	20,501	2,512	4,069	93.64
3,400	129,407	45,816	21,170	2,526	4,811	59.92	189,709	92,206	21,122	2,588	4,192	91.12
3,500	129,407	45,816	21,793	2,600	4,952	58.45	189,709	92,206	21,743	2,665	4,315	88.75
3,600	129,408	45,816	22,415	2,675	5,094	57.06	189,710	92,206	22,365	2,741	4,439	86.52
3,700	129,408	45,816	23,038	2,749	5,235	55.74	189,711	92,206	22,986	2,817	4,562	84.40
3,800	129,409	45,816	23,661	2,823	5,377	54.50	189,712	92,206	23,607	2,893	4,685	82.40
3,900	129,410	45,816	24,283	2,898	5,518	53.31	189,712	92,206	24,228	2,969	4,809	80.49
4,000	129,410	45,816	24,906	2,972	5,660	52.19	189,713	92,206	24,850	3,045	4,932	78.69
5,000	129,416	45,816	31,132	3,715	7,075	43.43	189,721	92,206	31,062	3,806	6,165	64.59
6,000	129,421	45,816	37,359	4,458	8,490	37.59	189,729	92,206	37,274	4,568	7,398	55.20
7,000	129,427	45,816	43,585	5,201	9,905	33.42	189,736	92,206	43,487	5,329	8,631	48.48
8,000	129,432	45,816	49,812	5,944	11,320	30.29	189,744	92,206	49,699	6,090	9,864	43.45
9,000	129,438	45,816	56,038	6,687	12,735	27.86	189,752	92,206	55,912	6,852	11,097	39.54
10,000	129,443	45,816	62,265	7,429	14,150	25.91	189,759	92,206	62,124	7,613	12,330	36.40
11,000	129,448	45,816	68,491	8,172	15,564	24.32	189,767	92,206	68,337	8,374	13,563	33.84
12,000	129,454	45,816	74,717	8,915	16,979	22.99	189,775	92,206	74,549	9,135	14,796	31.71
13,000	129,459	45,816	80,944	9,658	18,394	21.87	189,782	92,206	80,761	9,897	16,029	29.90
14,000							189,790	92,206	86,974	10,658	17,262	28.35
15,000							189,798	92,206	93,186	11,419	18,495	27.01

* Costs not reported when sales exceed equipment capacity.

** Changes in fixed costs reflect assumed positive relationship between facility land values and sales density.

Appendix Table 10. Fixed and variable costs related to volume and radius of sales area for specified sizes of dry fertilizer custom application for a 50 mile radius sales area, western North Dakota, 1992.

Annual sales	500 ton facility						800 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(tons)	(-	-	-	-	-	-	\$	-	-	-	-	-
100	42,606	13,890	623	62	113	572.95	45,549	18,348	623	62	113	646.95
200	42,606	13,890	1,247	124	226	290.47	45,549	18,348	1,247	124	226	327.47
300	42,606	13,890	1,870	186	340	196.31	45,549	18,348	1,870	186	340	220.97
400	42,606	13,890	2,493	248	453	149.23	45,549	18,348	2,493	248	453	167.73
500	42,606	13,890	3,117	310	566	120.98	45,549	18,348	3,117	310	566	135.78
600	42,607	13,890	3,740	371	679	102.15	45,549	18,348	3,740	371	679	114.48
700	42,607	13,890	4,364	433	793	88.69	45,549	18,348	4,364	433	793	99.27
800	42,607	13,890	4,987	495	906	78.61	45,550	18,348	4,987	495	906	87.86
900	42,607	13,890	5,610	557	1,019	70.76	45,550	18,348	5,610	557	1,019	78.98
1,000	42,607	13,890	6,234	619	1,132	64.48	45,550	18,348	6,234	619	1,132	71.88
1,100	42,607	13,890	6,857	681	1,245	59.35	45,550	18,348	6,857	681	1,245	66.07
1,200	42,607	13,890	7,480	743	1,359	55.07	45,550	18,348	7,480	743	1,359	61.23
1,300	42,607	13,890	8,104	805	1,472	51.44	45,550	18,348	8,104	805	1,472	57.14
1,400	42,607	13,890	8,727	867	1,585	48.34	45,550	18,348	8,727	867	1,585	53.63
1,500	42,607	13,890	9,351	929	1,698	45.65	45,550	18,348	9,351	929	1,698	50.58
1,600	42,607	13,890	9,974	991	1,812	43.30	45,550	18,348	9,974	991	1,812	47.92
1,700	42,607	13,890	10,597	1,052	1,925	41.22	45,550	18,348	10,597	1,052	1,925	45.57
1,800	42,607	13,890	11,221	1,114	2,038	39.37	45,551	18,348	11,221	1,114	2,038	43.48
1,900	42,607	13,890	11,844	1,176	2,151	37.72	45,551	18,348	11,844	1,176	2,151	41.62
2,000	42,607	13,890	12,467	1,238	2,265	36.23	45,551	18,348	12,467	1,238	2,265	39.93
2,100	42,607	13,890	13,091	1,300	2,378	34.89	45,551	18,348	13,091	1,300	2,378	38.41
2,200	42,607	13,890	13,714	1,362	2,491	33.67	45,551	18,348	13,714	1,362	2,491	37.03
2,300	42,607	13,890	14,338	1,424	2,604	32.55	45,551	18,348	14,338	1,424	2,604	35.77
2,400	42,607	13,890	14,961	1,486	2,717	31.53	45,551	18,348	14,961	1,486	2,717	34.61
2,500	42,608	13,890	15,584	1,548	2,831	30.58	45,551	18,348	15,584	1,548	2,831	33.54
2,600	42,608	13,890	16,208	1,610	2,944	29.72	45,551	18,348	16,208	1,610	2,944	32.56
2,700	42,608	13,890	16,831	1,672	3,057	28.91	45,552	18,348	16,831	1,672	3,057	31.65
2,800	42,608	13,890	17,454	1,733	3,170	28.16	45,552	18,348	17,454	1,733	3,170	30.81
2,900	42,608	13,890	18,078	1,795	3,284	27.47	45,552	18,348	18,078	1,795	3,284	30.02
3,000	42,608	13,890	18,701	1,857	3,397	26.82	45,552	18,348	18,701	1,857	3,397	29.28
3,100	42,608	13,890	19,325	1,919	3,510	26.21	45,552	18,348	19,325	1,919	3,510	28.60
3,200	42,608	13,890	19,948	1,981	3,623	25.64	45,552	18,348	19,948	1,981	3,623	27.95
3,300	42,608	13,890	20,571	2,043	3,736	25.11	45,552	18,348	20,571	2,043	3,736	27.35
3,400	42,608	13,890	21,195	2,105	3,850	24.60	45,552	18,348	21,195	2,105	3,850	26.78
3,500	42,608	13,890	21,818	2,167	3,963	24.13	45,552	18,348	21,818	2,167	3,963	26.24
3,600	42,608	13,890	22,441	2,229	4,076	23.68	45,553	18,348	22,441	2,229	4,076	25.74
3,700	42,608	13,890	23,065	2,291	4,189	23.25	45,553	18,348	23,065	2,291	4,189	25.26
3,800	42,608	13,890	23,688	2,353	4,303	22.85	45,553	18,348	23,688	2,353	4,303	24.80
3,900	42,608	13,890	24,312	2,414	4,416	22.47	45,553	18,348	24,312	2,414	4,416	24.37
4,000	42,608	13,890	24,935	2,476	4,529	22.11	45,553	18,348	24,935	2,476	4,529	23.96
5,000	42,609	13,890	31,169	3,095	5,661	19.28	45,554	18,348	31,169	3,095	5,661	20.77
6,000	42,609	13,890	37,402	3,715	6,794	17.40	45,555	18,348	37,402	3,715	6,794	18.64
7,000	42,610	13,890	43,636	4,334	7,926	16.06	45,556	18,348	43,636	4,334	7,926	17.11
8,000	42,610	13,890	49,870	4,953	9,058	15.05	45,557	18,348	49,870	4,953	9,058	15.97
9,000	42,611	13,890	56,104	5,572	10,190	14.26	45,558	18,348	56,104	5,572	10,190	15.09
10,000	42,612	13,890	62,337	6,191	11,323	13.64	45,559	18,348	62,337	6,191	11,323	14.38

cont'd.

Appendix Table 10. (cont'd.)

Annual sales	1,300 ton facility						2,000 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(tons)	(-	-	-	-	-	-	\$	-	-	-	-	-
100	99,131	18,348	623	62	113	1,182.77	121,638	45,816	623	83	198	1,683.58
200	99,131	18,348	1,246	124	226	595.37	121,638	45,816	1,246	166	397	846.31
300	99,132	18,348	1,868	186	340	399.58	121,638	45,816	1,868	250	595	567.22
400	99,132	18,348	2,491	248	453	301.68	121,638	45,816	2,491	333	793	427.68
500	99,132	18,348	3,114	310	566	242.94	121,639	45,816	3,114	416	992	343.95
600	99,132	18,348	3,737	371	679	203.78	121,639	45,816	3,737	499	1,190	288.14
700	99,132	18,348	4,359	433	793	175.81	121,639	45,816	4,359	582	1,388	248.27
800	99,132	18,348	4,982	495	906	154.83	121,639	45,816	4,982	665	1,587	218.36
900	99,133	18,348	5,605	557	1,019	138.51	121,640	45,816	5,605	748	1,785	195.11
1,000	99,133	18,348	6,228	619	1,132	125.46	121,640	45,816	6,228	832	1,984	176.50
1,100	99,133	18,348	6,851	681	1,245	114.78	121,640	45,816	6,851	915	2,182	161.28
1,200	99,133	18,348	7,473	743	1,359	105.88	121,640	45,816	7,473	998	2,380	148.59
1,300	99,133	18,348	8,096	805	1,472	98.35	121,641	45,816	8,096	1,081	2,579	137.86
1,400	99,133	18,348	8,719	867	1,585	91.89	121,641	45,816	8,719	1,164	2,777	128.66
1,500	99,134	18,348	9,342	929	1,698	86.30	121,641	45,816	9,342	1,247	2,975	120.68
1,600	99,134	18,348	9,964	991	1,812	81.40	121,642	45,816	9,964	1,331	3,174	113.70
1,700	99,134	18,348	10,587	1,052	1,925	77.09	121,642	45,816	10,587	1,414	3,372	107.55
1,800	99,134	18,348	11,210	1,114	2,038	73.25	121,642	45,816	11,210	1,497	3,570	102.08
1,900	99,134	18,348	11,833	1,176	2,151	69.81	121,642	45,816	11,833	1,580	3,769	97.18
2,000	99,134	18,348	12,456	1,238	2,265	66.72	121,643	45,816	12,456	1,663	3,967	92.77
2,100	99,134	18,348	13,078	1,300	2,378	63.92	121,643	45,816	13,078	1,746	4,165	88.79
2,200	99,135	18,348	13,701	1,362	2,491	61.38	121,643	45,816	13,701	1,830	4,364	85.16
2,300	99,135	18,348	14,324	1,424	2,604	59.06	121,643	45,816	14,324	1,913	4,562	81.85
2,400	99,135	18,348	14,947	1,486	2,717	56.93	121,644	45,816	14,947	1,996	4,761	78.82
2,500	99,135	18,348	15,570	1,548	2,831	54.97	121,644	45,816	15,570	2,079	4,959	76.03
2,600	99,135	18,348	16,192	1,610	2,944	53.16	121,644	45,816	16,192	2,162	5,157	73.45
2,700	99,135	18,348	16,815	1,672	3,057	51.49	121,644	45,816	16,815	2,245	5,356	71.07
2,800	99,136	18,348	17,438	1,733	3,170	49.94	121,645	45,816	17,438	2,328	5,554	68.85
2,900	99,136	18,348	18,061	1,795	3,284	48.49	121,645	45,816	18,061	2,412	5,752	66.79
3,000	99,136	18,348	18,683	1,857	3,397	47.14	121,645	45,816	18,683	2,495	5,951	64.86
3,100	99,136	18,348	19,306	1,919	3,510	45.88	121,646	45,816	19,306	2,578	6,149	63.06
3,200	99,136	18,348	19,929	1,981	3,623	44.69	121,646	45,816	19,929	2,661	6,347	61.37
3,300	99,136	18,348	20,552	2,043	3,736	43.58	121,646	45,816	20,552	2,744	6,546	59.79
3,400	99,137	18,348	21,175	2,105	3,850	42.53	121,646	45,816	21,175	2,827	6,744	58.30
3,500	99,137	18,348	21,797	2,167	3,963	41.55	121,647	45,816	21,797	2,911	6,942	56.89
3,600	99,137	18,348	22,420	2,229	4,076	40.61	121,647	45,816	22,420	2,994	7,141	55.56
3,700	99,137	18,348	23,043	2,291	4,189	39.73	121,647	45,816	23,043	3,077	7,339	54.30
3,800	99,137	18,348	23,666	2,353	4,303	38.90	121,647	45,816	23,666	3,160	7,537	53.11
3,900	99,137	18,348	24,288	2,414	4,416	38.10	121,648	45,816	24,288	3,243	7,736	51.98
4,000	99,138	18,348	24,911	2,476	4,529	37.35	121,648	45,816	24,911	3,326	7,934	50.91
5,000	99,139	18,348	31,139	3,095	5,661	31.48	121,651	45,816	31,139	4,158	9,918	42.54
6,000	99,141	18,348	37,367	3,715	6,794	27.56	121,653	45,816	37,367	4,989	11,901	36.95
7,000	99,142	18,348	43,595	4,334	7,926	24.76	121,656	45,816	43,595	5,821	13,885	32.97
8,000	99,144	18,348	49,822	4,953	9,058	22.67	121,659	45,816	49,822	6,653	15,868	29.98
9,000	99,146	18,348	56,050	5,572	10,190	21.03	121,661	45,816	56,050	7,484	17,852	27.65
10,000	99,147	18,348	62,278	6,191	11,323	19.73	121,664	45,816	62,278	8,316	19,836	25.79

cont'd.

Appendix Table 10. (cont'd.)

Annual sales	2,000 ton tower facility						4,000 ton facility					
	Fixed costs		Variable costs related to:			Total/ ton	Fixed costs		Variable costs related to:			Total/ ton
	Facility**	Equipment	Facility	Radius	Volume		Facility	Equipment	Facility	Radius	Volume	
(tons)	(-	-	-	-	-	-	\$	-	-	-	-	-)
100	129,389	45,816	623	83	198	1,761.09	189,683	92,206	621	91	172	2,827.73
200	129,389	45,816	1,245	166	397	885.07	189,683	92,206	1,242	181	345	1,418.29
300	129,389	45,816	1,868	250	595	593.06	189,684	92,206	1,864	272	517	948.47
400	129,389	45,816	2,491	333	793	447.06	189,684	92,206	2,485	362	689	713.57
500	129,390	45,816	3,113	416	992	359.45	189,684	92,206	3,106	453	862	572.62
600	129,390	45,816	3,736	499	1,190	301.05	189,685	92,206	3,727	543	1,034	478.66
700	129,390	45,816	4,359	582	1,388	259.34	189,685	92,206	4,349	634	1,206	411.54
800	129,390	45,816	4,981	665	1,587	228.05	189,686	92,206	4,970	724	1,379	361.21
900	129,391	45,816	5,604	748	1,785	203.72	189,686	92,206	5,591	815	1,551	322.05
1,000	129,391	45,816	6,226	832	1,984	184.25	189,686	92,206	6,212	906	1,723	290.73
1,100	129,391	45,816	6,849	915	2,182	168.32	189,687	92,206	6,834	996	1,896	265.11
1,200	129,391	45,816	7,472	998	2,380	155.05	189,687	92,206	7,455	1,087	2,068	243.75
1,300	129,392	45,816	8,094	1,081	2,579	143.82	189,687	92,206	8,076	1,177	2,240	225.68
1,400	129,392	45,816	8,717	1,164	2,777	134.19	189,688	92,206	8,697	1,268	2,413	210.19
1,500	129,392	45,816	9,340	1,247	2,975	125.85	189,688	92,206	9,319	1,358	2,585	196.77
1,600	129,393	45,816	9,962	1,331	3,174	118.55	189,689	92,206	9,940	1,449	2,757	185.03
1,700	129,393	45,816	10,585	1,414	3,372	112.11	189,689	92,206	10,561	1,539	2,930	174.66
1,800	129,393	45,816	11,208	1,497	3,570	106.38	189,689	92,206	11,182	1,630	3,102	165.45
1,900	129,393	45,816	11,830	1,580	3,769	101.26	189,690	92,206	11,804	1,720	3,274	157.21
2,000	129,394	45,816	12,453	1,663	3,967	96.65	189,690	92,206	12,425	1,811	3,447	149.79
2,100	129,394	45,816	13,076	1,746	4,165	92.48	189,690	92,206	13,046	1,902	3,619	143.08
2,200	129,394	45,816	13,698	1,830	4,364	88.68	189,691	92,206	13,667	1,992	3,791	136.98
2,300	129,394	45,816	14,321	1,913	4,562	85.22	189,691	92,206	14,289	2,083	3,964	131.41
2,400	129,395	45,816	14,943	1,996	4,761	82.05	189,692	92,206	14,910	2,173	4,136	126.30
2,500	129,395	45,816	15,566	2,079	4,959	79.13	189,692	92,206	15,531	2,264	4,308	121.60
2,600	129,395	45,816	16,189	2,162	5,157	76.43	189,692	92,206	16,152	2,354	4,481	117.26
2,700	129,395	45,816	16,811	2,245	5,356	73.93	189,693	92,206	16,774	2,445	4,653	113.25
2,800	129,396	45,816	17,434	2,328	5,554	71.62	189,693	92,206	17,395	2,535	4,825	109.52
2,900	129,396	45,816	18,057	2,412	5,752	69.46	189,693	92,206	18,016	2,626	4,998	106.05
3,000	129,396	45,816	18,679	2,495	5,951	67.45	189,694	92,206	18,637	2,716	5,170	102.81
3,100	129,397	45,816	19,302	2,578	6,149	65.56	189,694	92,206	19,258	2,807	5,342	99.78
3,200	129,397	45,816	19,925	2,661	6,347	63.80	189,695	92,206	19,880	2,898	5,515	96.94
3,300	129,397	45,816	20,547	2,744	6,546	62.14	189,695	92,206	20,501	2,988	5,687	94.27
3,400	129,397	45,816	21,170	2,827	6,744	60.58	189,695	92,206	21,122	3,079	5,859	91.75
3,500	129,398	45,816	21,793	2,911	6,942	59.10	189,696	92,206	21,743	3,169	6,032	89.38
3,600	129,398	45,816	22,415	2,994	7,141	57.71	189,696	92,206	22,365	3,260	6,204	87.15
3,700	129,398	45,816	23,038	3,077	7,339	56.40	189,696	92,206	22,986	3,350	6,376	85.03
3,800	129,398	45,816	23,661	3,160	7,537	55.15	189,697	92,206	23,607	3,441	6,549	83.03
3,900	129,399	45,816	24,283	3,243	7,736	53.97	189,697	92,206	24,228	3,531	6,721	81.12
4,000	129,399	45,816	24,906	3,326	7,934	52.85	189,698	92,206	24,850	3,622	6,893	79.32
5,000	129,402	45,816	31,132	4,158	9,918	44.09	189,701	92,206	31,062	4,527	8,617	65.22
6,000	129,404	45,816	37,359	4,989	11,901	38.25	189,705	92,206	37,274	5,433	10,340	55.83
7,000	129,407	45,816	43,585	5,821	13,885	34.07	189,709	92,206	43,487	6,338	12,063	49.11
8,000	129,410	45,816	49,812	6,653	15,868	30.94	189,713	92,206	49,699	7,244	13,786	44.08
9,000	129,412	45,816	56,038	7,484	17,852	28.51	189,716	92,206	55,912	8,149	15,510	40.17
10,000	129,415	45,816	62,265	8,316	19,836	26.56	189,720	92,206	62,124	9,055	17,233	37.03
11,000							189,724	92,206	68,337	9,960	18,956	34.47
12,000							189,728	92,206	74,549	10,866	20,680	32.34
13,000							189,731	92,206	80,761	11,771	22,403	30.53
14,000							189,735	92,206	86,974	12,676	24,126	28.98
15,000							189,739	92,206	93,186	13,582	25,850	27.64

* Costs not reported when sales exceed equipment capacity.

** Changes in fixed costs reflect assumed positive relationship between facility land values and sales density.

Appendix Table 11. Average costs by category for constant sales density of 10 tons/sq. mile by total annual sales and facility size, North Dakota, 1992.*

Annual sales	Radius of sales area	500 ton facility						800 ton facility					
		Average fixed costs		Average variable costs				Average fixed costs		Average variable costs			
		Facility	Equipment	Facility	Volume	Radius	ATC	Facility	Equipment	Facility	Volume	Radius	ATC
(tons)	(miles)	----- \$ -----											
100	5.60	426.48	6.23	218.60	1.40	0.12	652.84	514.06	6.23	392.82	2.02	0.10	915.24
200	7.93	213.24	6.23	109.30	1.40	0.16	330.34	257.03	6.23	196.41	2.01	0.18	461.87
300	9.71	142.16	6.23	72.87	1.40	0.19	222.85	171.35	6.23	130.94	2.00	0.24	310.76
400	11.21	106.62	6.23	54.65	1.40	0.22	169.12	128.52	6.23	98.21	1.99	0.29	235.23
500	12.53	85.30	6.23	43.72	1.40	0.24	136.89	102.81	6.23	78.56	1.99	0.33	189.93
600	13.73	71.08	6.23	36.43	1.39	0.26	115.41	85.68	6.23	65.47	1.99	0.37	159.74
700	14.83	60.93	6.23	31.23	1.39	0.28	100.07	73.44	6.23	56.12	1.98	0.40	138.18
800	15.85	53.31	6.23	27.33	1.39	0.30	88.56	64.26	6.23	49.10	1.98	0.44	122.01
900	16.81	47.39	6.23	24.29	1.39	0.32	79.62	57.12	6.23	43.65	1.98	0.47	109.45
1,000	17.72	42.65	6.23	21.86	1.39	0.34	72.47	51.41	6.23	39.28	1.98	0.50	99.40
1,100	18.59	38.77	6.23	19.87	1.39	0.35	66.62	46.73	6.23	35.71	1.97	0.53	91.18
1,200	19.42	35.54	6.23	18.22	1.39	0.37	61.75	42.84	6.23	32.74	1.97	0.55	84.33
1,300	20.21	32.81	6.23	16.82	1.39	0.38	57.62	39.54	6.23	30.22	1.97	0.58	78.54
1,400	20.97	30.46	6.23	15.61	1.39	0.39	54.09	36.72	6.23	28.06	1.97	0.61	73.58
1,500	21.71	28.43	6.23	14.57	1.39	0.41	51.03	34.27	6.23	26.19	1.97	0.63	69.29
1,600	22.42	26.66	6.23	13.66	1.39	0.42	48.36	32.13	6.23	24.55	1.96	0.65	65.53
1,700	23.11	25.09	6.23	12.86	1.39	0.43	46.00	30.24	6.23	23.11	1.96	0.67	62.22
1,800	23.78	23.69	6.23	12.14	1.39	0.44	43.90	28.56	6.23	21.82	1.96	0.70	59.27
1,900	24.43	22.45	6.23	11.51	1.38	0.46	42.03	27.06	6.23	20.67	1.96	0.72	56.64
2,000	25.07	21.32	6.23	10.93	1.38	0.47	40.34	25.70	6.23	19.64	1.96	0.74	54.27
2,100	25.69	20.31	6.23	10.41	1.38	0.48	38.81	24.48	6.23	18.71	1.96	0.76	52.13
2,200	26.29	19.39	6.23	9.94	1.38	0.49	37.43	23.37	6.23	17.86	1.95	0.78	50.19
2,300	26.88	18.54	6.23	9.50	1.38	0.50	36.16	22.35	6.23	17.08	1.95	0.80	48.42
2,400	27.46	17.77	6.23	9.11	1.38	0.51	35.00	21.42	6.23	16.37	1.95	0.82	46.79
2,500	28.02	17.06	6.23	8.74	1.38	0.52	33.94	20.56	6.23	15.71	1.95	0.84	45.30
2,600	28.58	16.40	6.23	8.41	1.38	0.53	32.96	19.77	6.23	15.11	1.94	0.85	43.91
2,700	29.12	15.80	6.23	8.10	1.38	0.54	32.05	19.04	6.23	14.55	1.94	0.87	42.63
2,800	29.66	15.23	6.23	7.81	1.38	0.55	31.20	18.36	6.23	14.03	1.94	0.89	41.45
2,900	30.18	14.71	6.23	7.54	1.38	0.56	30.42	17.73	6.23	13.55	1.94	0.91	40.35
3,000	30.70	14.22	6.23	7.29	1.38	0.57	29.68	17.14	6.23	13.09	1.94	0.92	39.32
3,100	31.21	13.76	6.23	7.05	1.38	0.58	29.00	16.58	6.23	12.67	1.93	0.94	38.36
3,200	31.71	13.33	6.23	6.83	1.38	0.58	28.36	16.06	6.23	12.28	1.93	0.96	37.46
3,300	32.20	12.92	6.23	6.62	1.38	0.59	27.75	15.58	6.23	11.90	1.93	0.97	36.62
3,400	32.68	12.54	6.23	6.43	1.38	0.60	27.19	15.12	6.23	11.55	1.93	0.99	35.83
3,500	33.16	12.19	6.23	6.25	1.38	0.61	26.65	14.69	6.23	11.22	1.93	1.00	35.08
3,600	33.63	11.85	6.23	6.07	1.38	0.62	26.15	14.28	6.23	10.91	1.93	1.02	34.37
3,700	34.09	11.53	6.23	5.91	1.38	0.63	25.67	13.89	6.23	10.62	1.93	1.03	33.71
3,800	34.55	11.22	6.23	5.75	1.38	0.64	25.22	13.53	6.23	10.34	1.93	1.05	33.08
3,900	35.00	10.94	6.23	5.61	1.38	0.64	24.80	13.18	6.23	10.07	1.93	1.06	32.48
4,000	35.45	10.66	6.23	5.47	1.38	0.65	24.39	12.85	6.23	9.82	1.93	1.08	31.91
5,000	39.63	8.53	6.23	4.37	1.38	0.73	21.24	10.28	6.23	7.86	1.92	1.22	27.51
6,000	43.42	7.11	6.23	3.64	1.37	0.79	19.15	8.57	6.23	6.55	1.91	1.34	24.60

cont'd.

Appendix Table 11. (cont'd.)

Annual sales	Radius of sales area	1,300 ton facility						2,000 ton facility					
		Average fixed costs		Average variable costs				Average fixed costs		Average variable costs			
		Facility	Equipment	Facility	Volume	Radius	ATC	Facility	Equipment	Facility	Volume	Radius	ATC
(tons)	(miles)	(- - - - - \$ - - - - -)											
100	5.60	992.58	6.23	771.51	1.84	0.08	1,772.23	1,218.48	6.23	1,268.47	1.84	0.07	2,495.09
200	7.93	496.29	6.23	385.76	1.83	0.15	890.25	609.24	6.23	634.24	1.83	0.13	1,251.66
300	9.71	330.86	6.23	257.17	1.83	0.20	596.28	406.16	6.23	422.82	1.83	0.18	837.21
400	11.21	248.14	6.23	192.88	1.82	0.24	449.31	304.62	6.23	317.12	1.82	0.22	630.00
500	12.53	198.52	6.23	154.30	1.82	0.28	361.14	243.70	6.23	253.69	1.82	0.25	505.69
600	13.73	165.43	6.23	128.59	1.81	0.32	302.37	203.08	6.23	211.41	1.82	0.28	422.82
700	14.83	141.80	6.23	110.22	1.81	0.35	260.40	174.07	6.23	181.21	1.82	0.31	363.64
800	15.85	124.07	6.23	96.44	1.80	0.38	228.92	152.31	6.23	158.56	1.81	0.34	319.25
900	16.81	110.29	6.23	85.72	1.80	0.41	204.44	135.39	6.23	140.94	1.81	0.37	284.73
1,000	17.72	99.26	6.23	77.15	1.80	0.43	184.87	121.85	6.23	126.85	1.81	0.39	257.12
1,100	18.59	90.23	6.23	70.14	1.79	0.46	168.85	110.77	6.23	115.32	1.81	0.41	234.54
1,200	19.42	82.71	6.23	64.29	1.79	0.48	155.51	101.54	6.23	105.71	1.81	0.44	215.72
1,300	20.21	76.35	6.23	59.35	1.79	0.51	144.22	93.73	6.23	97.57	1.81	0.46	199.80
1,400	20.97	70.90	6.23	55.11	1.79	0.53	134.55	87.03	6.23	90.61	1.80	0.48	186.15
1,500	21.71	66.17	6.23	51.43	1.79	0.55	126.17	81.23	6.23	84.56	1.80	0.50	174.33
1,600	22.42	62.04	6.23	48.22	1.79	0.57	118.84	76.15	6.23	79.28	1.79	0.52	163.97
1,700	23.11	58.39	6.23	45.38	1.78	0.59	112.37	71.68	6.23	74.62	1.79	0.54	154.85
1,800	23.78	55.14	6.23	42.86	1.78	0.61	106.63	67.69	6.23	70.47	1.79	0.55	146.74
1,900	24.43	52.24	6.23	40.61	1.78	0.63	101.49	64.13	6.23	66.76	1.79	0.57	139.48
2,000	25.07	49.63	6.23	38.58	1.78	0.65	96.86	60.92	6.23	63.42	1.79	0.59	132.95
2,100	25.69	47.27	6.23	36.74	1.78	0.67	92.68	58.02	6.23	60.40	1.79	0.61	127.05
2,200	26.29	45.12	6.23	35.07	1.78	0.68	88.88	55.39	6.23	57.66	1.79	0.62	121.68
2,300	26.88	43.16	6.23	33.54	1.78	0.70	85.41	52.98	6.23	55.15	1.79	0.64	116.78
2,400	27.46	41.36	6.23	32.15	1.78	0.72	82.23	50.77	6.23	52.85	1.79	0.65	112.29
2,500	28.02	39.70	6.23	30.86	1.78	0.73	79.30	48.74	6.23	50.74	1.79	0.67	108.16
2,600	28.58	38.18	6.23	29.67	1.77	0.75	76.60	46.86	6.23	48.79	1.79	0.68	104.35
2,700	29.12	36.76	6.23	28.57	1.77	0.77	74.10	45.13	6.23	46.98	1.78	0.70	100.82
2,800	29.66	35.45	6.23	27.55	1.77	0.78	71.79	43.52	6.23	45.30	1.78	0.71	97.54
2,900	30.18	34.23	6.23	26.60	1.77	0.80	69.63	42.02	6.23	43.74	1.78	0.73	94.49
3,000	30.70	33.09	6.23	25.72	1.77	0.81	67.61	40.62	6.23	42.28	1.78	0.74	91.65
3,100	31.21	32.02	6.23	24.89	1.77	0.83	65.73	39.31	6.23	40.92	1.78	0.75	88.99
3,200	31.71	31.02	6.23	24.11	1.77	0.84	63.97	38.08	6.23	39.64	1.78	0.77	86.49
3,300	32.20	30.08	6.23	23.38	1.76	0.86	62.30	36.92	6.23	38.44	1.78	0.78	84.15
3,400	32.68	29.19	6.23	22.69	1.76	0.87	60.74	35.84	6.23	37.31	1.78	0.79	81.95
3,500	33.16	28.36	6.23	22.04	1.76	0.88	59.27	34.81	6.23	36.24	1.78	0.81	79.87
3,600	33.63	27.57	6.23	21.43	1.76	0.90	57.88	33.85	6.23	35.24	1.78	0.82	77.91
3,700	34.09	26.83	6.23	20.85	1.76	0.91	56.57	32.93	6.23	34.28	1.78	0.83	76.05
3,800	34.55	26.12	6.23	20.30	1.75	0.92	55.33	32.07	6.23	33.38	1.78	0.84	74.30
3,900	35.00	25.45	6.23	19.78	1.75	0.94	54.15	31.24	6.23	32.52	1.78	0.86	72.63
4,000	35.45	24.81	6.23	19.29	1.75	0.95	53.03	30.46	6.23	31.71	1.78	0.87	71.05
5,000	39.63	19.85	6.23	15.43	1.75	1.07	44.33	24.37	6.23	25.37	1.76	0.98	58.71
6,000	43.42	16.54	6.23	12.86	1.74	1.18	38.56	20.31	6.23	21.14	1.76	1.08	50.52
7,000	46.89	14.18	6.23	11.02	1.74	1.29	34.45	17.41	6.23	18.12	1.76	1.18	44.69
8,000	50.13	12.41	6.23	9.64	1.73	1.38	31.39	15.23	6.23	15.86	1.76	1.26	40.34
9,000	53.17	11.03	6.23	8.57	1.72	1.47	29.02	13.54	6.23	14.09	1.76	1.35	36.97
10,000	56.05	9.93	6.23	7.72	1.72	1.55	27.14	12.18	6.23	12.68	1.75	1.42	34.27
11,000	58.79	9.02	6.23	7.01	1.72	1.63	25.62	11.08	6.23	11.53	1.75	1.50	32.08
12,000	61.40	8.27	6.23	6.43	1.72	1.71	24.36	10.15	6.23	10.57	1.75	1.57	30.27
13,000	63.91	7.64	6.23	5.93	1.72	1.78	23.30	9.37	6.23	9.76	1.75	1.63	28.75
14,000	66.32							8.70	6.23	9.06	1.75	1.70	27.45
15,000	68.65							8.12	6.23	8.46	1.76	1.76	26.33

cont'd.

Appendix Table 11. (cont').

Annual sales	Radius of sales area	2,000 ton tower facility						4,000 ton facility					
		Average fixed costs			Average variable costs			Average fixed costs			Average variable costs		
		Facility	Equipment	Facility	Volume	Radius	ATC	Facility	Equipment	Facility	Volume	Radius	ATC
(tons)	(miles)	(- - - - - \$ - - - - -)											
100	5.60	1,295.99	6.23	1,268.47	1.84	0.07	2,572.60	1,899.78	6.21	2,459.40	1.82	0.02	4,367.23
200	7.93	647.99	6.23	634.24	1.83	0.13	1,290.42	949.89	6.21	1,229.70	1.81	0.07	2,187.69
300	9.71	432.00	6.23	422.82	1.83	0.18	863.05	633.26	6.21	819.80	1.81	0.11	1,461.20
400	11.21	324.00	6.23	317.12	1.82	0.22	649.38	474.94	6.21	614.85	1.81	0.14	1,097.96
500	12.53	259.20	6.23	253.69	1.82	0.25	521.19	379.96	6.21	491.88	1.81	0.17	880.03
600	13.73	216.00	6.23	211.41	1.82	0.28	435.74	316.63	6.21	409.90	1.80	0.20	734.74
700	14.83	185.14	6.23	181.21	1.82	0.31	374.71	271.40	6.21	351.34	1.80	0.22	630.97
800	15.85	162.00	6.23	158.56	1.81	0.34	328.94	237.47	6.21	307.43	1.80	0.24	553.15
900	16.81	144.00	6.23	140.94	1.81	0.37	293.35	211.09	6.21	273.27	1.80	0.26	492.63
1,000	17.72	129.60	6.23	126.85	1.81	0.39	264.87	189.98	6.21	245.94	1.80	0.28	444.21
1,100	18.59	117.82	6.23	115.32	1.81	0.41	241.58	172.71	6.21	223.58	1.80	0.30	404.60
1,200	19.42	108.00	6.23	105.71	1.81	0.44	222.18	158.31	6.21	204.95	1.80	0.32	371.59
1,300	20.21	99.69	6.23	97.57	1.81	0.46	205.76	146.14	6.21	189.18	1.80	0.33	343.66
1,400	20.97	92.57	6.23	90.61	1.80	0.48	191.69	135.70	6.21	175.67	1.80	0.35	319.73
1,500	21.71	86.40	6.23	84.56	1.80	0.50	179.49	126.65	6.21	163.96	1.80	0.37	298.98
1,600	22.42	81.00	6.23	79.28	1.79	0.52	168.82	118.74	6.21	153.71	1.79	0.38	280.84
1,700	23.11	76.23	6.23	74.62	1.79	0.54	159.41	111.75	6.21	144.67	1.79	0.40	264.82
1,800	23.78	72.00	6.23	70.47	1.79	0.55	151.04	105.54	6.21	136.63	1.79	0.41	250.59
1,900	24.43	68.21	6.23	66.76	1.79	0.57	143.56	99.99	6.21	129.44	1.79	0.42	237.86
2,000	25.07	64.80	6.23	63.42	1.79	0.59	136.83	94.99	6.21	122.97	1.79	0.44	226.40
2,100	25.69	61.71	6.23	60.40	1.79	0.61	130.74	90.47	6.21	117.11	1.79	0.45	216.04
2,200	26.29	58.91	6.23	57.66	1.79	0.62	125.20	86.35	6.21	111.79	1.79	0.46	206.61
2,300	26.88	56.35	6.23	55.15	1.79	0.64	120.15	82.60	6.21	106.93	1.79	0.48	198.01
2,400	27.46	54.00	6.23	52.85	1.79	0.65	115.52	79.16	6.21	102.48	1.79	0.49	190.13
2,500	28.02	51.84	6.23	50.74	1.79	0.67	111.26	75.99	6.21	98.38	1.79	0.50	182.87
2,600	28.58	49.85	6.23	48.79	1.79	0.68	107.33	73.07	6.21	94.59	1.79	0.51	176.18
2,700	29.12	48.00	6.23	46.98	1.78	0.70	103.69	70.36	6.21	91.09	1.78	0.52	169.97
2,800	29.66	46.29	6.23	45.30	1.78	0.71	100.31	67.85	6.21	87.84	1.78	0.53	164.22
2,900	30.18	44.69	6.23	43.74	1.78	0.73	97.17	65.51	6.21	84.81	1.78	0.55	158.86
3,000	30.70	43.20	6.23	42.28	1.78	0.74	94.23	63.33	6.21	81.98	1.78	0.56	153.86
3,100	31.21	41.81	6.23	40.92	1.78	0.75	91.49	61.28	6.21	79.34	1.78	0.57	149.18
3,200	31.71	40.50	6.23	39.64	1.78	0.77	88.92	59.37	6.21	76.86	1.78	0.58	144.80
3,300	32.20	39.27	6.23	38.44	1.78	0.78	86.50	57.57	6.21	74.53	1.78	0.59	140.68
3,400	32.68	38.12	6.23	37.31	1.78	0.79	84.23	55.88	6.21	72.34	1.78	0.60	136.81
3,500	33.16	37.03	6.23	36.24	1.78	0.81	82.08	54.28	6.21	70.27	1.78	0.61	133.15
3,600	33.63	36.00	6.23	35.24	1.78	0.82	80.06	52.77	6.21	68.32	1.78	0.62	129.70
3,700	34.09	35.03	6.23	34.28	1.78	0.83	78.15	51.35	6.21	66.47	1.78	0.63	126.44
3,800	34.55	34.10	6.23	33.38	1.78	0.84	76.34	49.99	6.21	64.72	1.78	0.64	123.35
3,900	35.00	33.23	6.23	32.52	1.78	0.86	74.62	48.71	6.21	63.06	1.78	0.65	120.42
4,000	35.45	32.40	6.23	31.71	1.78	0.87	72.98	47.49	6.21	61.49	1.78	0.66	117.63
5,000	39.63	25.92	6.23	25.37	1.76	0.98	60.26	38.00	6.21	49.19	1.78	0.75	95.93
6,000	43.42	21.60	6.23	21.14	1.76	1.08	51.81	31.66	6.21	40.99	1.79	0.83	81.48
7,000	46.89	18.51	6.23	18.12	1.76	1.18	45.80	27.14	6.21	35.13	1.78	0.90	71.16
8,000	50.13	16.20	6.23	15.86	1.76	1.26	41.31	23.75	6.21	30.74	1.78	0.97	63.45
9,000	53.17	14.40	6.23	14.09	1.76	1.35	37.83	21.11	6.21	27.33	1.79	1.03	57.46
10,000	56.05	12.96	6.23	12.68	1.75	1.42	35.04	19.00	6.21	24.59	1.79	1.09	52.69
11,000	58.79	11.78	6.23	11.53	1.75	1.50	32.79	17.27	6.21	22.36	1.79	1.15	48.78
12,000	61.40	10.80	6.23	10.57	1.75	1.57	30.92	15.83	6.21	20.50	1.79	1.21	45.53
13,000	63.91	9.97	6.23	9.76	1.75	1.63	29.34	14.61	6.21	18.92	1.79	1.26	42.79
14,000	66.32	9.26	6.23	9.06	1.75	1.70	28.00	13.57	6.21	17.57	1.79	1.31	40.45
15,000	68.65	8.64	6.23	8.46	1.76	1.76	26.84	12.67	6.21	16.40	1.80	1.36	38.43

* Costs not reported when sales exceed equipment capacity.

Appendix Table 12. Average total costs by category for constant sales density of .5 tons/sq. mile by total annual sales and facility size, North Dakota, 1992.*

Annual sales	Radius of sales area	500 ton facility						800 ton facility					
		Average fixed costs		Average variable costs				Average fixed costs		Average variable costs			
		Facility	Equipment	Facility	Volume	Radius	ATC	Facility	Equipment	Facility	Volume	Radius	ATC
(tons)	(miles)	----- \$ -----						----- \$ -----					
100	25.07	426.08	6.23	138.90	0.56	0.20	571.98	744.19	6.23	183.48	0.56	0.20	934.66
200	35.45	213.04	6.23	69.45	0.56	0.27	289.56	372.09	6.23	91.74	0.56	0.27	470.90
300	43.42	142.03	6.23	46.30	0.55	0.33	195.45	248.06	6.23	61.16	0.55	0.33	316.34
400	50.13	106.52	6.23	34.73	0.55	0.38	148.41	186.05	6.23	45.87	0.55	0.38	239.08
500	56.05	85.22	6.23	27.78	0.55	0.42	120.20	148.84	6.23	36.70	0.55	0.42	192.74
600	61.40	71.01	6.23	23.15	0.55	0.46	101.41	124.03	6.23	30.58	0.55	0.46	161.85
700	66.32	60.87	6.23	19.84	0.55	0.49	87.99	106.31	6.23	26.21	0.55	0.49	139.80
800	70.90	53.26	6.23	17.36	0.55	0.52	77.93	93.02	6.23	22.93	0.55	0.52	123.27
900	75.20	47.34	6.23	15.43	0.55	0.55	70.11	82.69	6.23	20.39	0.55	0.55	110.41
1,000	79.27	42.61	6.23	13.89	0.55	0.58	63.87	74.42	6.23	18.35	0.55	0.58	100.13
1,100	83.14	38.73	6.23	12.63	0.55	0.61	58.76	67.65	6.23	16.68	0.55	0.61	91.73
1,200	86.83	35.51	6.23	11.58	0.55	0.64	54.50	62.02	6.23	15.29	0.55	0.64	84.73
1,300	90.38	32.78	6.23	10.68	0.55	0.66	50.91	57.25	6.23	14.11	0.55	0.66	78.81
1,400	93.79	30.43	6.23	9.92	0.55	0.69	47.83	53.16	6.23	13.11	0.55	0.69	73.73
1,500	97.08	28.41	6.23	9.26	0.55	0.71	45.16	49.61	6.23	12.23	0.55	0.71	69.34
1,600	100.27	26.63	6.23	8.68	0.56	0.73	42.83	46.51	6.23	11.47	0.56	0.73	65.50
1,700	103.35	25.06	6.23	8.17	0.56	0.75	40.78	43.78	6.23	10.79	0.56	0.75	62.11
1,800	106.35	23.67	6.23	7.72	0.56	0.77	38.95	41.34	6.23	10.19	0.56	0.77	59.10
1,900	109.26	22.43	6.23	7.31	0.56	0.79	37.32	39.17	6.23	9.66	0.56	0.79	56.41
2,000	112.10	21.30	6.23	6.95	0.56	0.81	35.86	37.21	6.23	9.17	0.56	0.81	53.99
2,100	114.87	20.29	6.23	6.61	0.56	0.83	34.54	35.44	6.23	8.74	0.56	0.83	51.81
2,200	117.57	19.37	6.23	6.31	0.57	0.85	33.33	33.83	6.23	8.34	0.57	0.85	49.82
2,300	120.21	18.53	6.23	6.04	0.57	0.87	32.24	32.36	6.23	7.98	0.57	0.87	48.01
2,400	122.80	17.75	6.23	5.79	0.57	0.89	31.23	31.01	6.23	7.64	0.57	0.89	46.35
2,500	125.33	17.04	6.23	5.56	0.57	0.91	30.31	29.77	6.23	7.34	0.57	0.91	44.82
2,600	127.81	16.39	6.23	5.34	0.57	0.93	29.46	28.62	6.23	7.06	0.57	0.93	43.41
2,700	130.25	15.78	6.23	5.14	0.58	0.94	28.68	27.56	6.23	6.80	0.58	0.94	42.11
2,800	132.64	15.22	6.23	4.96	0.58	0.96	27.95	26.58	6.23	6.55	0.58	0.96	40.90
2,900	134.99	14.69	6.23	4.79	0.58	0.98	27.28	25.66	6.23	6.33	0.58	0.98	39.78
3,000	137.29	14.20	6.23	4.63	0.59	0.99	26.65	24.81	6.23	6.12	0.59	0.99	38.73
3,100	139.56	13.74	6.23	4.48	0.59	1.01	26.06	24.01	6.23	5.92	0.59	1.01	37.76
3,200	141.80	13.32	6.23	4.34	0.59	1.02	25.51	23.26	6.23	5.73	0.59	1.02	36.84
3,300	143.99	12.91	6.23	4.21	0.60	1.04	24.99	22.55	6.23	5.56	0.60	1.04	35.98
3,400	146.16	12.53	6.23	4.09	0.60	1.06	24.51	21.89	6.23	5.40	0.60	1.06	35.17
3,500	148.29	12.17	6.23	3.97	0.60	1.07	24.05	21.26	6.23	5.24	0.60	1.07	34.41
3,600	150.40	11.84	6.23	3.86	0.61	1.09	23.62	20.67	6.23	5.10	0.61	1.09	33.69
3,700	152.47	11.52	6.23	3.75	0.61	1.10	23.21	20.11	6.23	4.96	0.61	1.10	33.02
3,800	154.52	11.21	6.23	3.66	0.61	1.11	22.83	19.58	6.23	4.83	0.61	1.11	32.37
3,900	156.54	10.93	6.23	3.56	0.62	1.13	22.47	19.08	6.23	4.70	0.62	1.13	31.77
4,000	158.53	10.65	6.23	3.47	0.62	1.14	22.12	18.60	6.23	4.59	0.62	1.14	31.19
5,000	177.25	8.52	6.23	2.78	0.67	1.27	19.48	14.88	6.23	3.67	0.67	1.27	26.73
6,000	194.16	7.10	6.23	2.32	0.74	1.39	17.78	12.40	6.23	3.06	0.74	1.39	23.83

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Appendix Table 12. (cont'd.)

Annual sales	Radius of sales area	1,300 ton facility						2,000 ton facility					
		Average fixed costs			Average variable costs			Average fixed costs			Average variable costs		
		Facility	Equipment	Facility	Volume	Radius	ATC	Facility	Equipment	Facility	Volume	Radius	ATC
(tons)	(miles)	(- - - - - \$ - - - - -)											
100	25.07	991.37	6.23	183.48	0.56	0.20	1,181.84	1,216.48	6.23	458.16	0.77	0.39	1,682.03
200	35.45	495.69	6.23	91.74	0.56	0.27	594.48	608.24	6.23	229.08	0.76	0.52	844.83
300	43.42	330.46	6.23	61.16	0.55	0.33	398.73	405.49	6.23	152.72	0.75	0.61	565.81
400	50.13	247.84	6.23	45.87	0.55	0.38	300.87	304.12	6.23	114.54	0.75	0.69	426.33
500	56.05	198.27	6.23	36.70	0.55	0.42	242.17	243.30	6.23	91.63	0.75	0.76	342.67
600	61.40	165.23	6.23	30.58	0.55	0.46	203.04	202.75	6.23	76.36	0.74	0.83	286.91
700	66.32	141.62	6.23	26.21	0.55	0.49	175.11	173.78	6.23	65.45	0.74	0.89	247.09
800	70.90	123.92	6.23	22.93	0.55	0.52	154.16	152.06	6.23	57.27	0.74	0.94	217.24
900	75.20	110.15	6.23	20.39	0.55	0.55	137.87	135.16	6.23	50.91	0.74	1.00	194.03
1,000	79.27	99.14	6.23	18.35	0.55	0.58	124.85	121.65	6.23	45.82	0.74	1.04	175.47
1,100	83.14	90.12	6.23	16.68	0.55	0.61	114.19	110.59	6.23	41.65	0.74	1.09	160.30
1,200	86.83	82.61	6.23	15.29	0.55	0.64	105.32	101.37	6.23	38.18	0.73	1.14	147.65
1,300	90.38	76.26	6.23	14.11	0.55	0.66	97.81	93.58	6.23	35.24	0.73	1.18	136.96
1,400	93.79	70.81	6.23	13.11	0.55	0.69	91.38	86.89	6.23	32.73	0.74	1.22	127.80
1,500	97.08	66.09	6.23	12.23	0.55	0.71	85.81	81.10	6.23	30.54	0.74	1.26	119.87
1,600	100.27	61.96	6.23	11.47	0.56	0.73	80.94	76.03	6.23	28.64	0.74	1.30	112.93
1,700	103.35	58.32	6.23	10.79	0.56	0.75	76.65	71.56	6.23	26.95	0.74	1.34	106.81
1,800	106.35	55.08	6.23	10.19	0.56	0.77	72.83	67.58	6.23	25.45	0.75	1.37	101.38
1,900	109.26	52.18	6.23	9.66	0.56	0.79	69.42	64.03	6.23	24.11	0.74	1.41	96.52
2,000	112.10	49.57	6.23	9.17	0.56	0.81	66.35	60.82	6.23	22.91	0.75	1.44	92.15
2,100	114.87	47.21	6.23	8.74	0.56	0.83	63.57	57.93	6.23	21.82	0.75	1.47	88.20
2,200	117.57	45.06	6.23	8.34	0.57	0.85	61.05	55.29	6.23	20.83	0.75	1.51	84.61
2,300	120.21	43.10	6.23	7.98	0.57	0.87	58.75	52.89	6.23	19.92	0.76	1.54	81.33
2,400	122.80	41.31	6.23	7.64	0.57	0.89	56.64	50.69	6.23	19.09	0.76	1.57	78.33
2,500	125.33	39.65	6.23	7.34	0.57	0.91	54.70	48.66	6.23	18.33	0.76	1.60	75.58
2,600	127.81	38.13	6.23	7.06	0.57	0.93	52.91	46.79	6.23	17.62	0.76	1.63	73.03
2,700	130.25	36.72	6.23	6.80	0.58	0.94	51.26	45.05	6.23	16.97	0.77	1.66	70.68
2,800	132.64	35.41	6.23	6.55	0.58	0.96	49.73	43.45	6.23	16.36	0.77	1.69	68.50
2,900	134.99	34.19	6.23	6.33	0.58	0.98	48.30	41.95	6.23	15.80	0.78	1.72	66.47
3,000	137.29	33.05	6.23	6.12	0.59	0.99	46.97	40.55	6.23	15.27	0.78	1.74	64.57
3,100	139.56	31.98	6.23	5.92	0.59	1.01	45.72	39.24	6.23	14.78	0.79	1.77	62.81
3,200	141.80	30.98	6.23	5.73	0.59	1.02	44.56	38.01	6.23	14.32	0.79	1.80	61.15
3,300	143.99	30.04	6.23	5.56	0.60	1.04	43.46	36.86	6.23	13.88	0.80	1.83	59.60
3,400	146.16	29.16	6.23	5.40	0.60	1.06	42.44	35.78	6.23	13.48	0.80	1.85	58.14
3,500	148.29	28.32	6.23	5.24	0.60	1.07	41.47	34.76	6.23	13.09	0.81	1.88	56.76
3,600	150.40	27.54	6.23	5.10	0.61	1.09	40.55	33.79	6.23	12.73	0.81	1.90	55.46
3,700	152.47	26.79	6.23	4.96	0.61	1.10	39.69	32.88	6.23	12.38	0.82	1.93	54.23
3,800	154.52	26.09	6.23	4.83	0.61	1.11	38.87	32.01	6.23	12.06	0.82	1.95	53.07
3,900	156.54	25.42	6.23	4.70	0.62	1.13	38.10	31.19	6.23	11.75	0.83	1.98	51.97
4,000	158.53	24.78	6.23	4.59	0.62	1.14	37.36	30.41	6.23	11.45	0.84	2.00	50.93
5,000	177.25	19.83	6.23	3.67	0.67	1.27	31.67	24.33	6.23	9.16	0.92	2.23	42.86
6,000	194.16	16.52	6.23	3.06	0.74	1.39	27.94	20.27	6.23	7.64	1.02	2.43	37.59

cont'd.

Appendix Table 12. (cont'd.)

Annual sales	Radius of sales area	2,000 ton tower facility						4,000 ton facility					
		Average fixed costs			Average variable costs			Average fixed costs			Average variable costs		
		Facility	Equipment	Facility	Volume	Radius	ATC	Facility	Equipment	Facility	Volume	Radius	ATC
(tons)	(miles)	(- - - - - \$ - - - - -)											
100	25.07	1,293.99	6.23	458.16	0.77	0.39	1,759.54	1,896.97	6.21	922.06	0.74	0.35	2,826.33
200	35.45	646.99	6.23	229.08	0.76	0.52	883.58	948.49	6.21	461.03	0.73	0.46	1,416.92
300	43.42	431.33	6.23	152.72	0.75	0.61	591.64	632.32	6.21	307.35	0.73	0.54	947.16
400	50.13	323.50	6.23	114.54	0.75	0.69	445.71	474.24	6.21	230.51	0.73	0.61	712.31
500	56.05	258.80	6.23	91.63	0.75	0.76	358.17	379.39	6.21	184.41	0.73	0.67	571.42
600	61.40	215.66	6.23	76.36	0.74	0.83	299.82	316.16	6.21	153.68	0.72	0.73	477.50
700	66.32	184.86	6.23	65.45	0.74	0.89	258.16	271.00	6.21	131.72	0.73	0.78	410.44
800	70.90	161.75	6.23	57.27	0.74	0.94	226.93	237.12	6.21	115.26	0.73	0.83	360.15
900	75.20	143.78	6.23	50.91	0.74	1.00	202.64	210.77	6.21	102.45	0.73	0.87	321.04
1,000	79.27	129.40	6.23	45.82	0.74	1.04	183.22	189.70	6.21	92.21	0.73	0.91	289.76
1,100	83.14	117.64	6.23	41.65	0.74	1.09	167.34	172.45	6.21	83.82	0.73	0.95	264.17
1,200	86.83	107.83	6.23	38.18	0.73	1.14	154.11	158.08	6.21	76.84	0.73	0.99	242.86
1,300	90.38	99.54	6.23	35.24	0.73	1.18	142.92	145.92	6.21	70.93	0.74	1.03	224.83
1,400	93.79	92.43	6.23	32.73	0.74	1.22	133.34	135.50	6.21	65.86	0.74	1.06	209.38
1,500	97.08	86.27	6.23	30.54	0.74	1.26	125.03	126.46	6.21	61.47	0.74	1.10	195.99
1,600	100.27	80.87	6.23	28.64	0.74	1.30	117.77	118.56	6.21	57.63	0.75	1.13	184.28
1,700	103.35	76.12	6.23	26.95	0.74	1.34	111.37	111.59	6.21	54.24	0.75	1.16	173.95
1,800	106.35	71.89	6.23	25.45	0.75	1.37	105.68	105.39	6.21	51.23	0.75	1.20	164.78
1,900	109.26	68.10	6.23	24.11	0.74	1.41	100.59	99.84	6.21	48.53	0.76	1.23	156.57
2,000	112.10	64.70	6.23	22.91	0.75	1.44	96.02	94.85	6.21	46.10	0.77	1.26	149.18
2,100	114.87	61.62	6.23	21.82	0.75	1.47	91.88	90.33	6.21	43.91	0.77	1.28	142.50
2,200	117.57	58.82	6.23	20.83	0.75	1.51	88.13	86.23	6.21	41.91	0.77	1.31	136.43
2,300	120.21	56.26	6.23	19.92	0.76	1.54	84.70	82.48	6.21	40.09	0.78	1.34	130.90
2,400	122.80	53.92	6.23	19.09	0.76	1.57	81.56	79.04	6.21	38.42	0.78	1.37	125.82
2,500	125.33	51.76	6.23	18.33	0.76	1.60	78.68	75.88	6.21	36.88	0.79	1.39	121.16
2,600	127.81	49.77	6.23	17.62	0.76	1.63	76.01	72.96	6.21	35.46	0.80	1.42	116.85
2,700	130.25	47.93	6.23	16.97	0.77	1.66	73.55	70.26	6.21	34.15	0.81	1.44	112.87
2,800	132.64	46.21	6.23	16.36	0.77	1.69	71.26	67.75	6.21	32.93	0.81	1.47	109.17
2,900	134.99	44.62	6.23	15.80	0.78	1.72	69.14	65.41	6.21	31.80	0.81	1.49	105.73
3,000	137.29	43.13	6.23	15.27	0.78	1.74	67.16	63.23	6.21	30.74	0.82	1.52	102.52
3,100	139.56	41.74	6.23	14.78	0.79	1.77	65.31	61.19	6.21	29.74	0.83	1.54	99.52
3,200	141.80	40.44	6.23	14.32	0.79	1.80	63.57	59.28	6.21	28.81	0.84	1.56	96.71
3,300	143.99	39.21	6.23	13.88	0.80	1.83	61.95	57.48	6.21	27.94	0.85	1.59	94.07
3,400	146.16	38.06	6.23	13.48	0.80	1.85	60.42	55.79	6.21	27.12	0.86	1.61	91.59
3,500	148.29	36.97	6.23	13.09	0.81	1.88	58.98	54.20	6.21	26.34	0.87	1.63	89.26
3,600	150.40	35.94	6.23	12.73	0.81	1.90	57.61	52.69	6.21	25.61	0.87	1.65	87.04
3,700	152.47	34.97	6.23	12.38	0.82	1.93	56.33	51.27	6.21	24.92	0.88	1.68	84.96
3,800	154.52	34.05	6.23	12.06	0.82	1.95	55.11	49.92	6.21	24.26	0.89	1.70	82.99
3,900	156.54	33.18	6.23	11.75	0.83	1.98	53.96	48.64	6.21	23.64	0.90	1.72	81.12
4,000	158.53	32.35	6.23	11.45	0.84	2.00	52.87	47.42	6.21	23.05	0.91	1.74	79.34
5,000	177.25	25.88	6.23	9.16	0.92	2.23	44.41	37.94	6.21	18.44	1.04	1.93	65.57
6,000	194.16	21.57	6.23	7.64	1.02	2.43	38.88	31.62	6.21	15.37	1.22	2.11	56.53
7,000	209.72							27.10	6.21	13.17	1.48	2.27	50.24
8,000	224.20							23.71	6.21	11.53	1.87	2.42	45.74

* Costs not reported when sales exceed equipment capacity.

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