The Economics of On-Farm Storage

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

The interest in grain storage in Kansas and other states has escalated recently. This interest can be attributed to increased yields due to improved technology and genetics, wide basis levels at harvest, and a shift to more corn acres due to the growing number of ethanol plants being constructed. More specifically, corn generally has higher yields than other competing grain crops, requiring more storage room, or otherwise replaces crops not dependent on conventional storage, for example, cotton or alfalfa. The rising demand for storage has led to grain being stored in temporary structures, the leasing of old facilities, and a renewed interest in the construction of new storage structures.

Kansas traditionally has stored the majority of its grain production in commercial elevators, as opposed to in on-farm storage facilities (Figure 1). In 2006, on-farm storage capacity in Kansas was approximately 31 percent of the total storage capacity in the state, compared to an average of about 57 percent across the United States. Year-to-year total storage capacity in Kansas trended downward from 1987 to 1997 before increasing in the late 1990s and remaining relatively constant since 2000. The increase in storage capacity from 1997 to 2000 was primarily with off-farm storage rather than on-farm storage. In 2006, on-farm and off-farm storage capacities were estimated at 395 and 890 million bushels, respectively, totaling 1.285 billion bushels of total grain storage capacity in Kansas. This compares to 1.142 billion bushels of storage capacity in 1997.

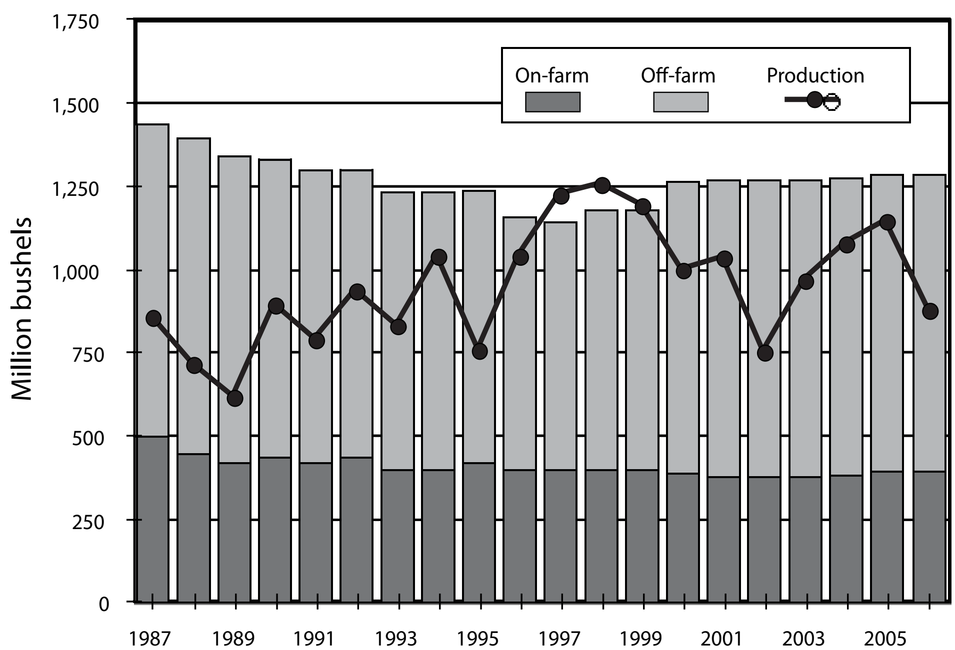
Total production of the four major grain crops in Kansas (wheat, corn, grain sorghum, and soybeans) peaked in the late 1990s and generally has been down since that time (Figure 1). This decline in production has been due to total planted acres decreasing slightly (net of decreases in wheat and sorghum and increases in corn and soybean acres) and relatively poor yields due to unfavorable weather in a number of those years. Total production of these four crops exceeded storage capacity in the late 1990s, which put pressure on the state's ability to store grain and led to the increase in storage capacity in 2000. However, since 2000, production levels have been below the peak levels of the late 1990s and the storage pressure that existed at that time generally has not prevailed in the state, at least on average – though on a regional basis there have been some instances of storage pressures.

Since 1987 total storage capacity in Kansas has been above a billion bushels (on-farm grain storage data first became available in 1986). From 1987 through 2006 total production of the four major grain crops ranged from 617 to 1,253 million bushels, with total production surpassing a billion bushels eight times. Given the current trend towards more corn acres and assuming a return to trend yields, without expansion storage capacity in Kansas likely would be strained in futures years as it was in the late 1990s. However, a question that arises is, Will this expansion be with additional commercial storage, or will it take place at the farm level?

Effects of Ethanol

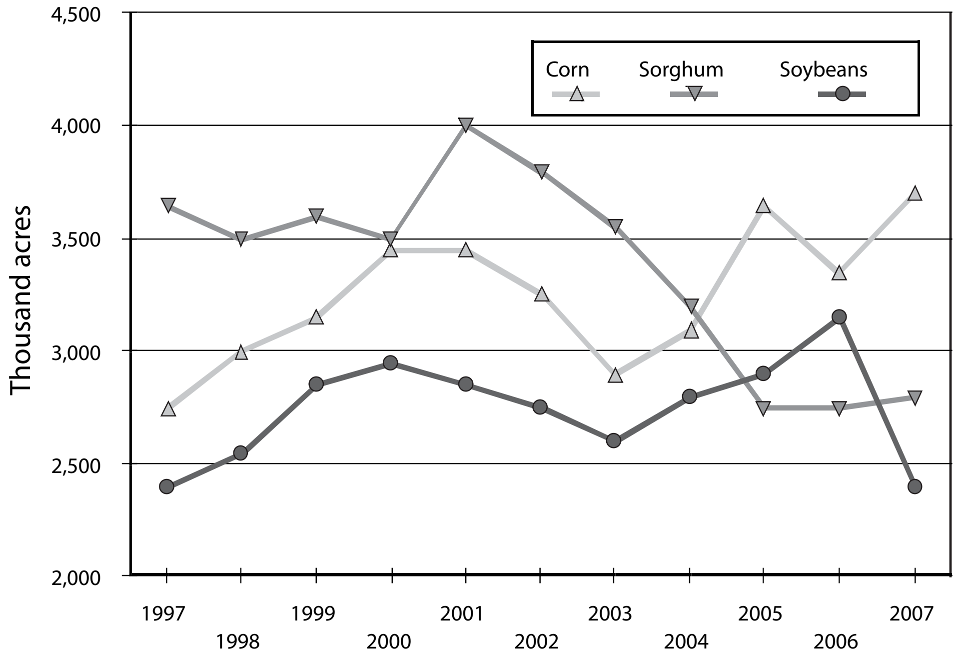
The current trend toward significantly higher levels of ethanol production potentially plays the largest role in the increased interested of on-farm storage. In June 2007, eight ethanol plants were

Figure 1. *Grain (wheat, corn, grain sorghum, and soybeans) production versus storage capacity in Kansas.*



Source: *USDA Grain Stocks report and Kansas Ag Statistics*

Figure 2. *Kansas planted acres of corn, sorghum, and soybeans, 1997-2007.*



Source: *Kansas Agricultural Statistics Service*

ignores the large demand for corn from the Kansas feedlot industry. As prices of commodities change to reflect this increased demand, producers will have an incentive to replace wheat and soybean acres with higher-yielding corn acres and those added bushels will result in the need for additional grain storage capacity.

Considering corn, grain sorghum, and soybeans, which often compete for the same acres, the number of acres planted to corn has increased significantly compared to grain sorghum and soybeans (Figure 2). Grain sorghum acres have decreased considerably since 2001, being replaced by corn and soybeans. However, in response to increased ethanol production, planting intentions for 2007, as of June 2007, suggest a large drop in soybean acres, with corn acreage increasing and sorghum acreage remaining steady to increasing slightly compared to 2006.

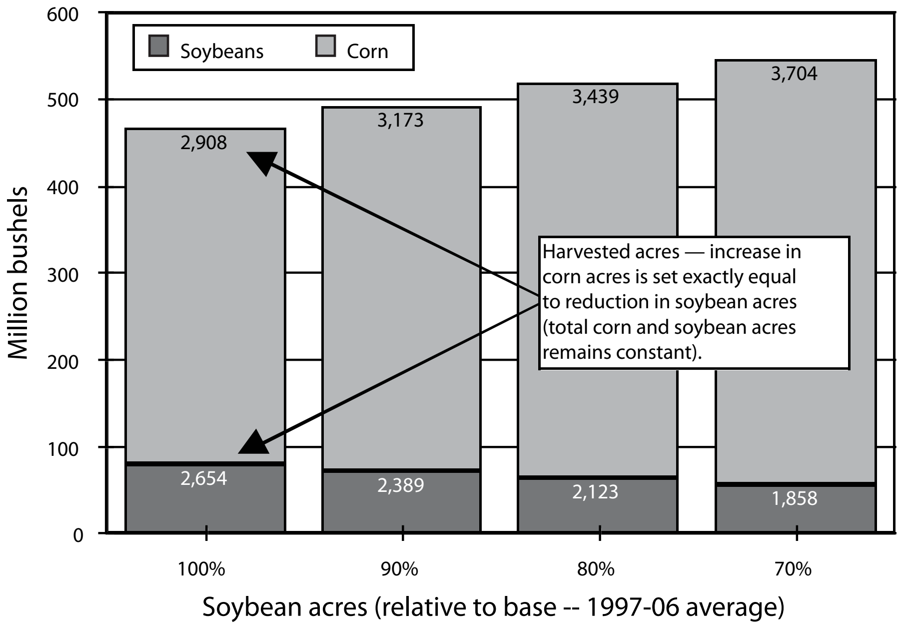
The additional corn production most likely will arise from grain producers switching planted acres from soybeans to corn. Once acres have been switched from soybeans to corn, the bushels of production drastically increase per acre. For example, in 2006, the statewide average yield for soybeans was 32 bushels per acre while the statewide average corn yield was 115 bushels per acre. These numbers suggest the average corn yield was more than three times the average soybean yield. From 1997 to 2006, the ratio of corn yield to soybean yield has been 4.5, suggesting an even larger effect than might have been observed in 2006. From 1997 to 2006, harvested acreage of corn and soybeans has been 2.908 and 2.654 million acres, respectively. Figure 3 shows how total production of corn and soybeans would increase as soybean acres are replaced with corn acres holding yields constant at 1997 through 2006 averages (132.4 bushels per acre for corn and 30.4 for soybeans). The combined production of the two crops for the base scenario (1997 through 2006

in operation in Kansas, producing 215.5 million gallons per year (MGPY). At that time, six additional plants were under construction, which would add another 300 million gallons of annual production. Finally, an additional 10 plants are under consideration, which would produce another 856 million gallons of ethanol per year (Kansas Ethanol).

It is estimated that a bushel of corn or sorghum produces 2.6 to 2.8 gallons of ethanol, which means that each additional 100 MGPY of ethanol production requires approximately 37 million bushels of corn or sorghum. Thus, current plants demand about 80 million bushels of corn annually, while plants under construction and under consideration would have an additional annual demand of 111 and 317 million bushels, respectively.

If all proposed plants were completed, total annual demand for corn, just for Kansas ethanol plants, would be approximately 508 million bushels. Kansas corn production averaged slightly over 414 million bushels annually for the years 2004 through 2006. To supply ethanol plants currently in operation in Kansas, about 19 percent of this production would have been used. However, the corn required to supply existing and all proposed ethanol plants would require almost 123 percent of the average annual production for 2004 through 2006. This completely

Figure 3. Annual production resulting in switching from soybean to corn acres.



average) was 466.6 million bushels. Assuming 20 percent of the soybean acres were diverted to corn, the total production of the two crops would increase more than 50 million bushels, to nearly 520 million bushels (+11.4 percent). Thus, it can be seen how switching crops in response to changing relative prices induced by policies regarding ethanol production and use can impact grain storage needs in Kansas.

The next issue becomes where to store the added bushels of production. Because ethanol plants typically store 14 days worth of corn needed for ethanol production, the remaining corn needed must be stored in off- and on-farm storage facilities (Patrico, 2007).

In addition to holding grain to capture seasonal price strength, an advantage may exist for producers to store corn that potentially will be sold to ethanol plants. At least it appears that ethanol plants are not averse to buying corn from farmers. In particular, a survey of Iowa ethanol plants found an average of 62 percent of ethanol plants purchased corn directly from farmers. In addition, ethanol plant managers also have been known to offer price premium incentives for deliveries at specific times (Hardy and Holz-Clause). This could be a benefit of grain storage as opposed to selling at harvest.

On-Farm Storage

While Kansas has historically relied heavily on off-farm (commercial) storage, a number of factors may lead to future increases in the amount of on-farm storage. In addition to the increased demand associated with ethanol production, several additional reasons for the interest in on-farm storage are (1) increasing acreage of specialty crops and the need to preserve the identity of crops; (2) farmers changing their crop mixes due to production flexibility; (3) producers using larger trucks, making it easier for them to haul grain directly to its final destination, thereby bypassing local grain elevators; (4) harvest time bottleneck concerns; and (5) to a lesser extent, grain quality issues.

As producers increase their acreage of specialty crops or crops that require identity preservation, commercial storage may not be a viable alternative and thus on-farm storage is necessary. Additionally, as producers change their crop mix (i.e., plant more summer crops and less wheat), on-farm storage may be more economical if producing multiple crops allows bins to be used for more months out of the year.

Producers using larger trucks often have more flexibility as to where their crops are marketed, increasing the benefit of on-farm storage relative to commercial storage. On the other hand, producers who historically have had on-farm storage because of distances to commercial elevators, will find it easier to haul directly to elevators during harvest as they increase the size of their trucks. Large operators also may find that on-farm storage facilities reduce bottlenecks associated with smaller and older commercial storage facilities (i.e., facilities that were not designed to accommodate semi-trucks).

The advent of automatic grain quality sensing equipment has reduced some of the historical concerns with quality issues associated with on-farm storage. Furthermore, producers storing grain on-farm may see gains in quality with the ability to manage optimal moisture content of grain compared to commercial storage.

Temporary storage facilities are a 'quick-fix' option to a grain surplus. However, it becomes harder to ensure grain quality because of increased moisture present and the lack of aeration, which may cause damaged kernels and promote mold and insect infestations (Patrico, 2007). Another less-costly choice may be to add additional rings to existing bins to increase capacity. Finally, a long-term solution is to build permanent on-farm grain storage bins with or without grain handling systems. Regardless of why producers consider constructing on-farm storage facilities, doing so requires a capital investment, and thus analyzing the costs and returns associated with this investment is important.

It is important to note that the above statements refer more to increased demand for grain storage in general, either off- or on-farm. In fact, nearly every one of the arguments could be construed as more supportive of commercial rather than on-farm storage. Commercial elevators in Kansas with grain storage historically have responded to market signals regarding grain storage quite well, as indicated in Figure 1. They constantly consider the potential for identity preserving crops. They regularly update grain handling equipment to handle larger trucks and reduce harvest-time bottlenecks. They routinely deal with truck or rail delivery to accommodate grain buyers. Through the increased efficiency related to volume, they have become astute users of temporary storage techniques. Finally, they routinely have a role to play even for on-farm storage, where they regularly become the brokers between livestock or ethanol users of grains and farmers who have grain stored on their farms. So, if history is any guide, it is likely that off-farm storage in Kansas will not diminish in importance in the coming years relative to on-farm storage.

On-Farm Storage Costs

Grain storage costs have both fixed and variable components. Fixed costs are incurred regardless of whether grain actually is stored in storage facilities, whereas variable costs are incurred only when grain is stored. In this sense, fixed costs are the cost of owning the storage facilities (i.e., depreciation, interest, taxes, and insurance). In a decision-making framework, fixed costs are irrelevant — decisions are made solely on variable costs. In other words, a producer who can cover the variable costs of storage should store grain regardless of whether or not fixed costs can be covered. However, it is important to remember that before facilities are constructed, all costs are variable. Therefore, when making the investment decision to construct on-farm storage facilities all costs (variable and fixed) should be considered. Moreover, even once investments in storage structures have been made, managers should strive to cover both fixed and variable costs – at least if the goal is to keep such facilities useful into the future.

Fixed Costs

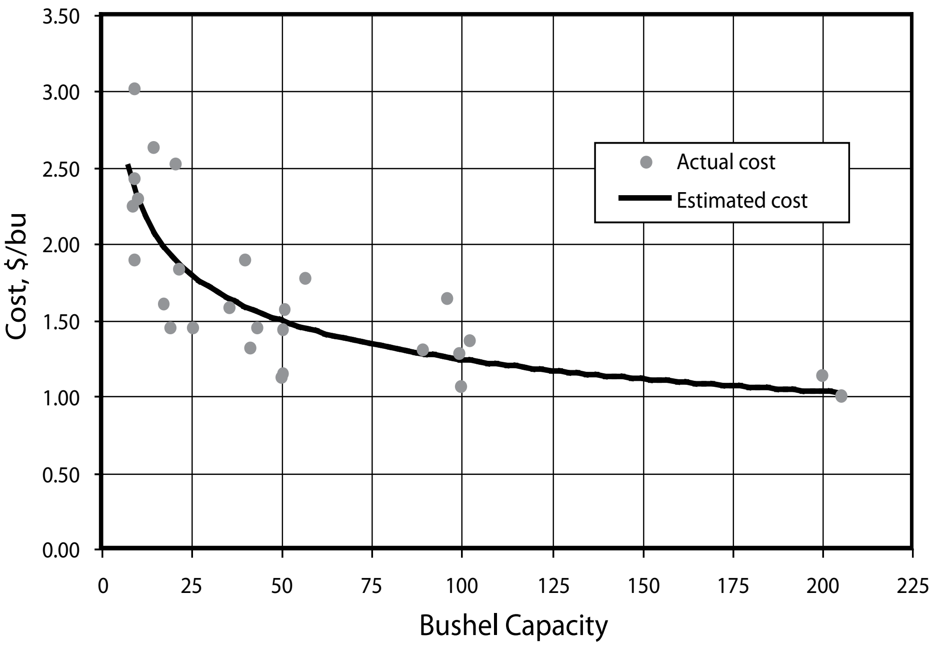
The fixed costs of owning storage facilities are those costs that are incurred annually, regardless of whether the facilities are used. The fixed costs of owning facilities are depreciation, interest, taxes, and insurance. While fixed costs technically are not considered when making management decisions (i.e., to store or not to store), if a producer is considering building new facilities, these costs need to be considered because they are still variable costs at that point.

The total annual fixed cost of storage facilities depends on the size of the investment. Grain bin cost data were collected from several manufacturers.[1] All manufacturers reported the price of a base bin and its capacity and some manufacturers reported accessory and aeration equipment. The cost of accessory and aeration equipment for those manufacturers not reporting this information were estimated based on those that did report this information. Bin capacities range from approximately 9,000 to 200,000 bushels. The costs collected did not include monitoring equipment, conveyance equipment, concrete, site preparation, or construction. The authors estimated the costs associated with site preparation, concrete, and construction.

Because revenue (i.e., grain price) is assessed on a per bushel basis, the relevant investment scale to consider is the investment *per bushel* of capacity. Therefore, all costs were converted to a per bushel basis. Using this cost information, a model was developed to estimate cost as a function of bin size (Figure 4). This model illustrates that investment required on a per bushel basis, decreases, but at a decreasing rate, as bin size

1 *Grain bin manufacturers included Behlen, Brock, GSI, MFS, and Titan.*

Figure 4. *Grain bin investment (includes bin, aeration equipment, site preparation, concrete, and construction.)*



increases. For example, the model-estimated investment for a 10,000 bushel bin is $2.31 per bushel compared to $1.80, $1.49, and $1.24 for 25,000, 50,000, and 100,000 bushel bins, respectively. Thus, there clearly are economies of size regarding investment required on a per bushel basis (i.e., larger bins cost less per bushel of storage to purchase).

While the model estimated provides some insight as to what grain bin costs might be, there are several other considerations when estimating the investment required for on-farm storage facilities. First, bin cost varies widely, depending on options and types of equipment (e.g., fans, floor types, and supports). Second, when planning for a larger system, the producer might consider installing a high-temperature grain dryer. The investment required for a dryer also will vary considerably due to type of dryer (e.g., heat only versus heating and cooling), capacity, etc., and so it is important to consider how this will impact the total investment required of the grain handling system. In addition, the location of the storage facilities, as well as future expansion plans, can affect the total investment.

Once a producer has estimated the total investment for the storage facilities being considered, annual fixed costs can be estimated. Table 1 shows the fixed cost per bushel for four different bin sizes (10,000; 25,000; 50,000; and 100,000 bushels) based on the estimated bin investment values shown in Figure 4. An investment per bushel also is included for a portable auger, where the investment is assumed to be proportional to bin investment across bin sizes. Depreciation equals the investment divided by the useful life (i.e., a straight-line depreciation is used). Interest is based on the interest portion of an amortized loan payment where the interest rate used (6.56 percent) is the average between the government Commodity Credit Corporation (CCC) loan rate (4.265 percent) and an operating loan rate (8.5 percent). Taxes and insurance are based on the original investment. Based on the useful life assumptions (30 years for bins and 20 years for conveyance equipment and other) and an interest rate of 6.56 percent, fixed costs range from 20.9¢ per bushel for a 10,000-bushel bin to 11.2¢ for a 100,000-bushel bin. Thus, there are fairly large economies of size associated with larger bins in terms of ownership costs.

In many cases, a producer will not construct a single grain bin. Rather, an entire storage system will be constructed, which includes multiple bins, aeration equipment, and conveyance equipment.

Table 2 shows total cost per bushel including materials, construction, and conveyance for storage systems with capacities ranging from 50,000 to 220,000 bushels. Figures A1-A4 in the appendix show the layouts as well as the number and sizes of bins for each of these systems. The site selection and layout considerations for each individual system may differ and are addressed later in this publication. The fixed costs for the grain storage systems range from 30.4¢ per bushel for a 50,000-bushel system to 18.5¢ for a 220,000-bushel system. These costs are considerably higher than those reported in Table 1 due to the increased investment of conveyance equipment (e.g., dump pit, grain pump, or bucket elevator). However, as with individual bins, there are

Table 1. *Individual Bin Cost*

	Useful Life	Bin Size (bushels)				Your Farm
Initial Investment ($/bu)		10,000	25,000	50,000	100,000	
Bin Investment	30	$2.31	$1.80	$1.49	$1.24	
Conveyance Equip.	20	$0.08	$0.06	$0.05	$0.04	____________
Other	20	$0.08	$0.06	$0.05	$0.04	____________
Total Investment		$2.47	$1.92	$1.59	$1.32	____________
Annual Costs ($/bu)						
Depreciation		$0.085	$0.066	$0.055	$0.045	____________
Interest[1]	6.56%	$0.107	$0.084	$0.069	$0.058	____________
Taxes and Insurance	0.7%	$0.017	$0.013	$0.011	$0.009	____________
Total Fixed Costs		$0.209	$0.163	$0.135	$0.112	____________
Variable Costs ($/bu)						
Utilities (electricity, etc.)						
Conveyance[2]		$0.019	$0.019	$0.019	$0.019	____________
Drying		$0.000	$0.000	$0.000	$0.000	____________
Aeration		$0.013	$0.013	$0.013	$0.013	____________
Insecticide[3]		$0.025	$0.020	$0.015	$0.010	____________
Repairs, % of investment	1.5%	$0.037	$0.029	$0.024	$0.020	____________
Interest[4]	6.56%	$0.112	$0.112	$0.112	$0.112	____________
Shrinkage[5]		$0.055	$0.055	$0.055	$0.055	____________
Total Variable Costs		$0.261	$0.248	$0.238	$0.229	____________
Total Farm Storage Costs ($/bu)						
		$0.470	$0.411	$0.373	$0.341	____________

[1] *Interest portion of ammortized payment using average of CCC loan rate and operating loan rate*
[2] *Represents variable cost of tractor used on auger*
[3] *Includes bin wall spray, protectant, and fumigant*
[4] *Based on storing wheat for 6 months and harvest price of $3.41/bu.*
[5] *Based on (1% shrink + additional 0.1% x 6 months of storage) x price of $3.41/bu.*

economies of size associated with larger storage systems in terms of ownership costs.

Variable Costs

The variable costs of on-farm storage can be broken down into onetime and ongoing components. For example, the cost of handling the grain is a onetime cost that is constant regardless of how long the grain is stored. Costs such as monitoring, aeration, and shrinkage, may be ongoing and depend on how long the grain is stored. Table 1 shows a breakdown of the variable costs of storing grain for four different bin sizes. For a 25,000-bushel bin the variable costs (excluding interest on the grain) are 11.5¢ per bushel for the onetime component and 0.34¢ per bushel per month of storage due to shrinkage.[2] The 11.5¢ cost represents conveyance, aeration, repairs, insecticide application, and shrinkage that are incurred due to storing grain but are independent of how long the grain is stored. The additional 0.34¢ per bushel per month is based on additional shrinkage assumed to occur as grain is stored longer. Drying is listed as a variable cost, as it may be incurred if grain is stored. However, it is important for producers to realize that they implicitly pay drying costs for all wet grain

2 *The variable costs associated with on-farm storage likely depend on the size of the facility. For example, labor associated with handling grain on a per bushel basis likely is less with larger bins than with small bins. In this analysis, no differentiation is made to variable costs with regard to bins size, with the exception of insecticide.*

Table 2. *Storage System Cost*

	Useful Life	Storage Capacity (bushels)[1]				Your Farm
Initial Investment ($/bu)		50,000	95,000	163,100	220,000	
Bin Investment ($/bu)	30	$2.17	$2.03	$1.83	$1.61	____________
Conveyance Equip. ($/bu)	20	$1.14	$1.04	$0.71	$0.44	____________
Other	20	$0.10	$0.09	$0.08	$0.07	____________
Total Investment		$3.41	$3.16	$2.62	$2.12	____________
Annual Costs ($/bu)						
Depreciation		$0.134	$0.124	$0.101	$0.079	____________
Interest[2]	6.56%	$0.146	$0.136	$0.112	$0.091	____________
Taxes and Insurance	0.7%	$0.024	$0.022	$0.018	$0.015	____________
Total Fixed Costs		$0.304	$0.282	$0.231	$0.185	____________
Variable Costs ($/bu)						
Utilities (electricity, etc.)						
Conveyance		$0.011	$0.009	$0.008	$0.008	____________
Drying		$0.000	$0.000	$0.000	$0.000	____________
Aeration		$0.013	$0.013	$0.013	$0.013	____________
Insecticide[3]		$0.040	$0.030	$0.020	$0.010	____________
Repairs, % of investment	1.5%	$0.051	$0.047	$0.039	$0.032	____________
Interest[4]	6.56%	$0.112	$0.112	$0.112	$0.112	____________
Shrinkage[5]		$0.055	$0.055	$0.055	$0.055	____________
Total Variable Costs		$0.282	$0.266	$0.247	$0.230	____________
Total Farm Storage Costs ($/bu)						
		$0.586	$0.548	$0.478	$0.415	____________

[1] *See figures A1-A4 for system layouts.*
[2] *Interest portion of ammortized payment using average of CCC loan rate and operating loan rate*
[3] *Includes bin wall spray, protectant, and fumigant*
[4] *Based on storing wheat for 6 months and harvest price of $3.41/bu.*
[5] *Based on (1% shrink + additional 0.1% x 6 months of storage) x price of $3.41/bu.*

whether they store the grain or not, and thus drying costs have been ignored in this example. Table 2 shows similar variable cost information for the various grain storage systems.[3]

Interest Cost

The other cost of storing grain is interest cost. Interest cost is incurred because holding the grain does not allow the producer to either pay off debt or invest the income from the grain (i.e., the opportunity cost of not selling). The interest cost of storing can approach, or even exceed, the physical cost of storage. Consider the following example for storing wheat for 6 months:

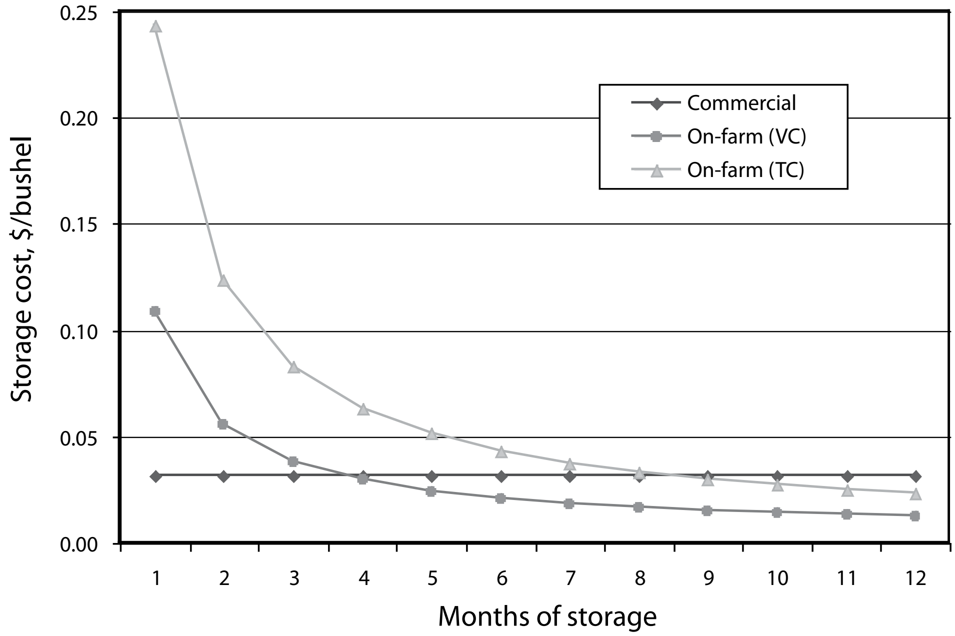
Wheat harvest price		$3.41 (5-year (2002/03-2006/07) average harvest price)
Interest rate	×	6.56%
Months of storage	×	6
Months in a year	÷	12
Interest cost	=	11.2¢ per bushel

Based on the values in Table 1 for a 25,000-bushel grain bin, the physical variable cost of storage in this example would be 13.1¢ per bushel (11.2¢ + 0.32¢ × 6 months). Thus, interest cost is a major part of the total storage cost and should not be overlooked.

3 *An Excel spreadsheet, On-farm storage.xls, is available at www.agmanager.info that can be used to generate budgets such as those displayed in tables 1 and 2.*

Commercial vs. On-Farm Storage

Figure 5. *Commercial versus on-farm monthly storage cost (50,000-bushel bin)*



Because historically the majority of grain storage in Kansas has been off-farm, a comparison of on-farm versus commercial storage costs is warranted. From a producer's perspective, commercial storage costs are characterized as being variable cost only (i.e., no costs are incurred unless grain is stored). Statewide commercial storage costs averaged about 3.13¢ per bushel per month in June 2007.[4]

Figure 5 compares the on-farm storage cost of a 50,000-bushel bin (Table 1) with the commercial storage cost based on the number of months of storage. Interest cost on the grain (i.e., opportunity cost of not selling at harvest) has not been included in this figure as it would be the same for both on-farm and commercial storage. On-farm storage costs, on a per-bushel-per-month basis, are higher than commercial storage costs if the grain is stored for a short time period, due to the onetime component of handling the grain. However, when the grain is stored for longer time periods the commercial storage cost is greater than the on-farm cost. The breakeven point (point where on-farm storage and commercial storage costs are equal), based on the assumptions used here, is between 3 and 4 months when only variable costs (VC) are considered. Therefore, if grain is stored 4 months or longer, the variable costs of on-farm storage are less than the costs of commercial storage. The breakeven point for total costs (TC), which is fixed costs plus variable costs, is between 8 and 9 months based on the assumptions used in this example.

Historical Seasonality of Prices

For many producers, grain is stored in order to capture seasonal price improvements. Figures 6 through 9 show 10- and 30-year average seasonal price indices in Kansas for wheat, corn, grain sorghum, and soybeans, respectively, for the crop years 1976/77 through 2005/06 (1977/78 to 2006/07 for wheat).[5] As one would expect, prices are lowest at harvest on average and then increase over time as harvest-provided grain supplies are used up during the ensuing year.

Seasonal price indices can be used to predict the price in a given month, based on the harvest price. This is done in the following manner. First, divide the harvest price by the harvest month index. This gives the expected average annual price. Then multiply this number by any month's index to obtain the expected price in that particular month. Using this approach, producers can estimate how much prices would be expected to increase postharvest based on historical seasonal price patterns. Expected price increases then can be compared to the costs of on-farm storage to determine whether grain storage would be profitable based on seasonal price movements. Examples for each crop are shown in Table 3 using the 30-year average seasonal indices with the cash price for wheat and harvest-delivery forward contract bids for corn, grain sorghum, and soybeans in McPherson, Kansas on July 23, 2007.

Figures 10 and 11 show the expected returns to storing wheat, corn, grain sorghum, and

4 *Based on an average of survey (June 2007) values from seven Kansas commercial storage facilities.*

5 *An Excel spreadsheet, Grain_Seasonals_Cash.xls, is available at www.agmanager.info that can be used to generate seasonal price indices for corn, grain sorghum, soybeans, and wheat by region in Kansas over varying time periods.*

Figure 6. *Average monthly price indices for wheat in Kansas, 1977/78—2006/07.*

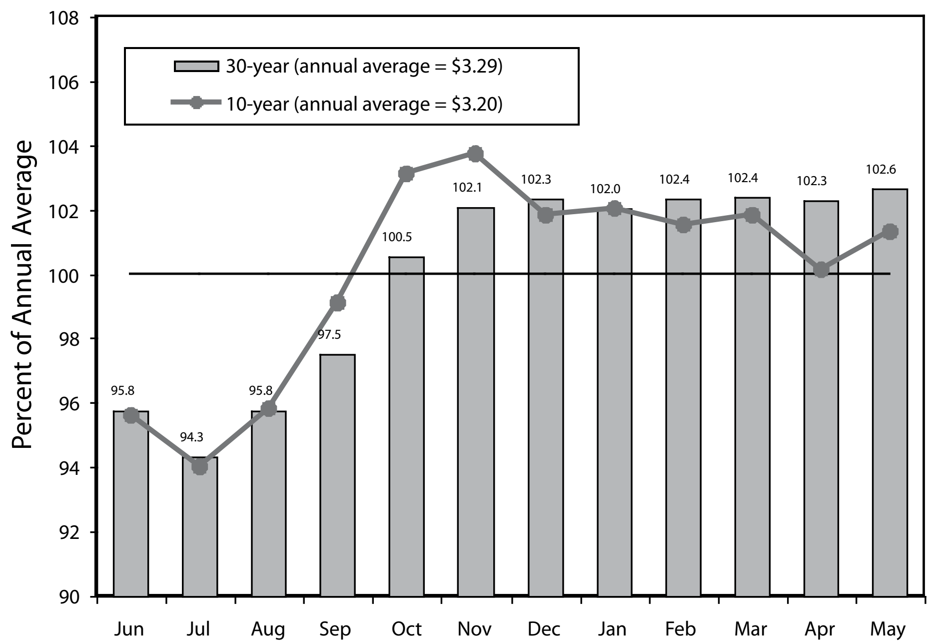
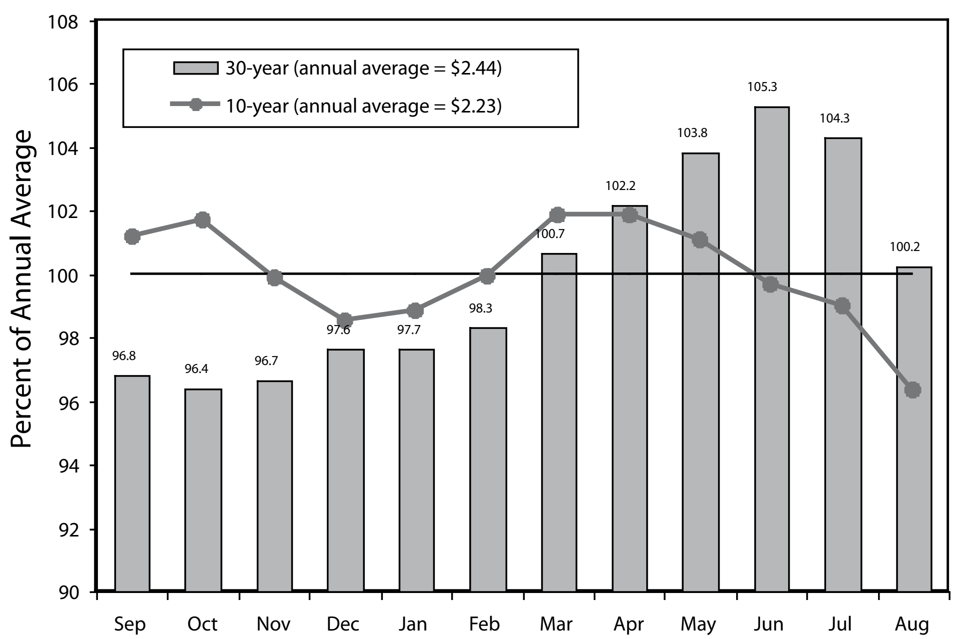


Figure 7. *Average monthly price indices for corn in Kansas, 1976/77—2005/06.*



soybeans based on the expected price increases in Table 3 and the total storage costs per bushel in Tables 1 and 2, respectively, where costs have been adjusted to account for harvest price and months of storage specific to each crop (values in parenthesis in figures are months crop is stored postharvest). It can be seen that returns to storing wheat are only positive with the larger bins that have lower costs due to the smaller per-bushel investment (Figure 10). Regardless of bin size, returns are expected to be positive for storing soybeans but negative for storing corn or sorghum. With the higher investment associated with an entire grain-handling system (i.e., bin, conveyance system, pit), returns are positive for soybeans but negative for wheat, corn, and sorghum across all storage system sizes considered (Figure 11). Thus, based on 30-year average historical price indices and total costs used here, storing grains, especially corn and grain sorghum, to simply capture seasonal price increases has not been particularly profitable.

Table 4 shows similar information as Table 3 except that the most recent 10-year average seasonal indices are used. Expected price increases are similar for wheat and soybeans, but considerably less for corn and grain sorghum. Corn actually shows a price decline from October to June based on the last 10 years. Examining Figure 7 it can be seen that over the last 10 years, on average, based on price movements, there has been no incentive to store corn past March. This reveals how dependent seasonal price indices are on the time period being analyzed and that considerable price risk exists when storing grain. Thus, while historical price patterns can be used as a guide to determine if grain storage will be profitable, it is important to recognize that changing market fundamentals (i.e., ethanol) will likely alter these historical relationships.

Figure 8. *Average monthly price indices for grain sorghum in Kansas, 1976/77—2005/06.*

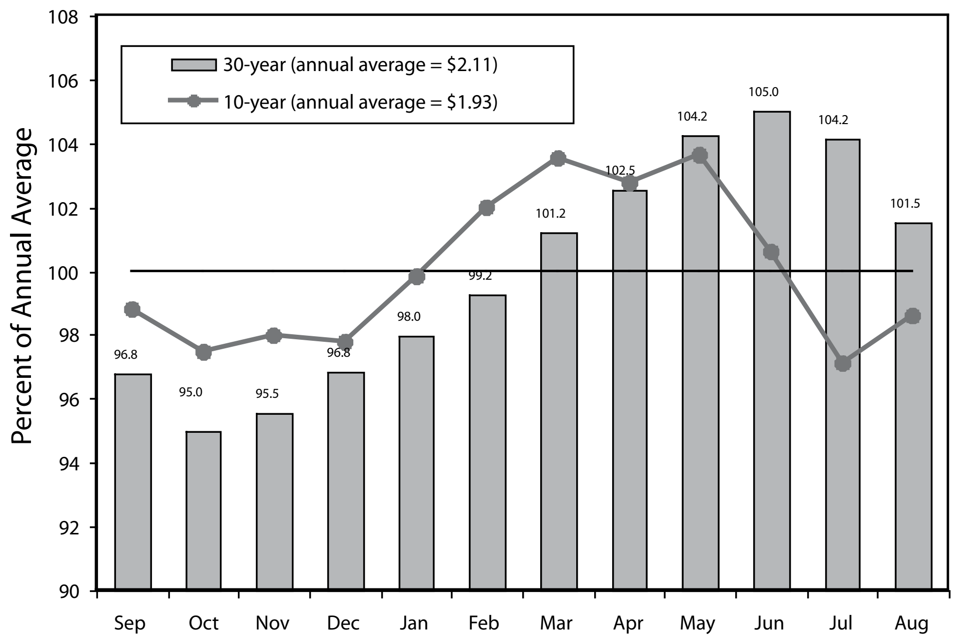
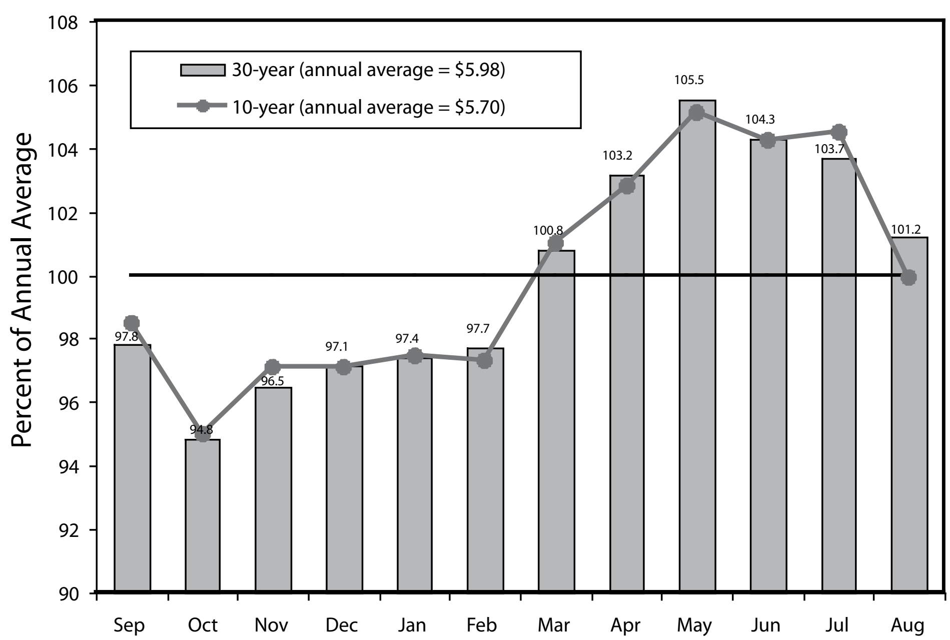


Figure 9. *Average monthly price indices for soybeans in Kansas, 1976/77—2005/06.*



Should I Invest in On-Farm Storage Facilities?

Does it seem reasonable for a producer to invest in on-farm storage facilities? Given the information presented so far, if the returns to storage are simply capturing seasonal price moves, the answer is probably not. For example, based on the assumptions in Table 1 for a 25,000-bushel bin and the harvest prices and number of storage months (wheat-5, corn-8, grain sorghum-8, and soybeans-7) listed in Table 3, the variable costs would be 32.3¢, 26.9¢, 24.9¢, and 49.4¢ per bushel for wheat, corn, grain sorghum, and soybeans, respectively.

With these same assumptions, expected price increases would be 48¢, 28¢, 29¢, and 84¢ per bushel for wheat, corn, grain sorghum, and soybeans, respectively. This indicates that, on average, seasonal price increases will generate a small positive return over variable costs for grain stored between 5 and 8 months (i.e., the expected price increase in Table 3 is greater than the variable costs).[6] However, when the fixed costs of 16.3¢ per bushel are included, the average returns become negative for corn and grain sorghum and basically reflect a breakeven for wheat. Remember, prior to purchasing storage facilities, ownership costs are still variable and thus relevant in the decision-making process. Furthermore, the risk of storing grain has been ignored here, as these numbers only consider what would be expected on average.

Based on this information, it is evident that, on average, seasonal price increases are not large enough to cover the total costs of on-farm storage — at least not with the assumptions used in this analysis. However, the current interest in on-farm storage suggests there are benefits not factored into this analysis. The following are some possible advantages of on-farm storage compared to commercial storage:

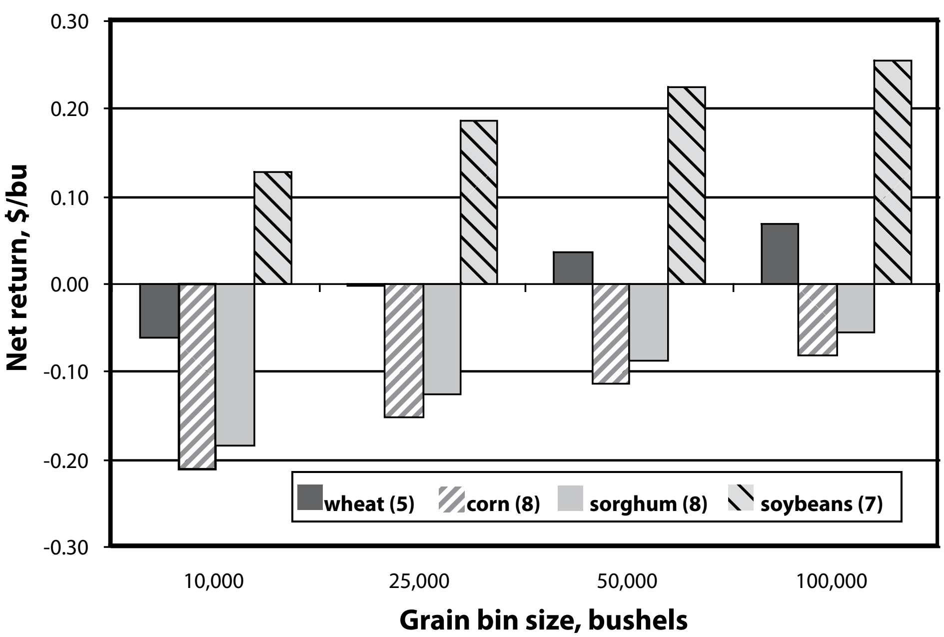
6 For a more detailed look at historical returns to storing grain at various locations in Kansas see Dhuyvetter (1999).

Table 3. Examples of Using 30-Year Average Seasonal Indices to Predict Prices

		Crop			
		Wheat	Corn	Grain Sorghum	Soybeans
A.	Harvest month	July	October	October	October
B.	Harvest price[1]	$5.71	$3.04	$2.72	$7.47
C.	Monthly index[2]	0.943	0.964	0.950	0.948
D.	Annual price (B/C)	$6.06	$3.15	$2.86	$7.88
E.	Storage month	December	June	June	May
F.	Monthly index[2]	1.023	1.053	1.05	1.055
G.	Expected price (D x F)	$6.19	$3.32	$3.01	$8.31
H.	Price increase (G-B)[3]	$0.48	$0.28	$0.29	$0.84

[1] *Cash bid for wheat and harvest delivery forward contract bids for corn, grain sorghum and soybeans in McPherson, Kansas (July 23, 2007).*
[2] *Values from figures 6-9 in decimal form.*
[3] *Expected price increase if prices follow the same pattern as they have over the previous 30 years.*

Figure 10. *Returns to storing wheat, corn, grain sorghum, and soybeans based on crop prices in Table 3 and costs in Table 1 adjusted for respective harvest price and months stored.*



But, once again, keep in mind that several of the above points might also apply to commercial storage. For example, storage space is routinely guaranteed by commercial elevators if desired. Identity preservation might even be more efficiently handled by commercial elevators if they have equipment lacking on the farm (e.g., protein testers). Also, as noted earlier, harvest-time bottlenecks might actually be better handled in commercial facilities.

In years when commercial storage space is tight, producers may have to pay a "dumping charge" to store grain commercially. In addition, when storage space is tight, an alternative is to store grain on the ground or in temporary facilities. The risk of quality loss increases significantly in these situations. In some years, storing may not even be an option, as has been the case in some locations in Kansas. In these situations, the benefit of owning on-farm storage facilities has not been factored into the analysis. The value of this advantage, when averaged over many years, is likely to be fairly small because commercial storage tends to be available for most producers in most years.

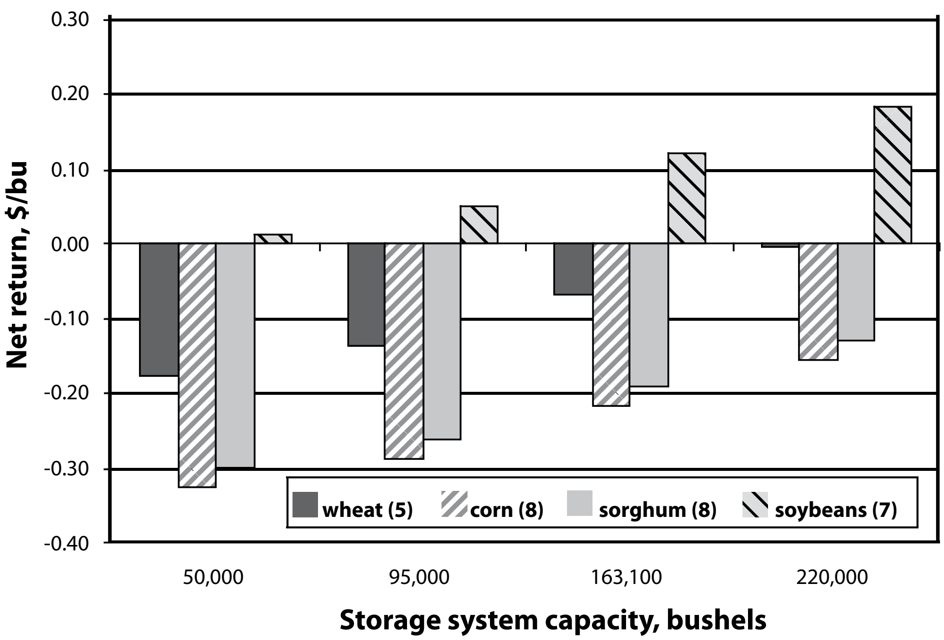
- Storage space is likely available when needed.
- Marketing flexibility increases.
- Grain identity can be preserved.
- Bottlenecks and quality considerations are reduced.
- Grain is readily available for on-farm livestock.
- Variable costs may be less than commercial storage cost.
- Government subsidized loans may exist for on-farm but not off-farm grain storage facility construction.

Table 4. *Examples of Using 10-Year Average Seasonal Indices to Predict Prices*

		Crop			
		Wheat	Corn	Grain Sorghum	Soybeans
A.	Harvest month	July	October	October	October
B.	Harvest price[1]	$5.71	$3.04	$2.72	$7.47
C.	Monthly index[2]	0.940	1.017	0.975	0.950
D.	Annual price (B/C)	$6.07	$2.99	$2.79	$7.86
E.	Storage month	December	June	June	May
F.	Monthly index[2]	1.019	0.997	1.006	1.051
G.	Expected price (D x F)	$6.19	$2.98	$2.81	$8.26
H.	Price increase (G-B)[3]	$0.48	-$0.06	$0.09	$0.79

[1] *Cash bid for wheat and harvest delivery forward contract bids for corn, grain sorghum and soybeans in McPherson, Kansas (July 23, 2007).*
[2] *Values from figures 6-9 in decimal form.*
[3] *Expected price increase if prices follow the same pattern as they have over the previous 10 years.*

Figure 11. *Returns to storing wheat, corn, grain sorghum, and soybeans based on crop prices in Table 3 and costs in Table 2 adjusted for respective harvest price and months stored.*



A benefit of on-farm storage often cited by producers is increased marketing flexibility. For example, when grain is stored commercially, it typically is sold to that elevator. While elevators may allow producers to take grain out of storage and sell it elsewhere, there usually is an in-/out-charge (June 2007 survey values ranged from 17¢ to 27¢ per bushel) that offsets the benefit of marketing elsewhere.

Another benefit of marketing flexibility not captured in these figures has to do with truck bids. Producers often indicate that they can receive premiums of 10¢ to 20¢ per bushel on truck bids relative to elevator bids — particularly for feed grains in western Kansas. This premium is primarily due to no in-/out-charge being incurred at the elevator, but it also may be related to quality issues. For example, feedyards might consider farm-stored grain to be of higher quality for feed processing, because it is less likely to have been dried with heat and or less/likely to have been handled as often with grain conveyance equipment. Similar to

Moreover, in years when storage space is in large supply, it could be that a portion of commercial storage charges are implicitly "forgiven" via the price offerings obtained, offsetting some of the tight-storage-year benefits of on-farm storage. Regardless, the tight-storage-year benefit of on-farm storage should be considered in the nearby future. That is, given current production and storage capacity trends, storage shortages may occur more often in the near future.

corn going to feedlots, this "truck bid premium" may likewise exist for delivering corn to ethanol plants. But, as noted earlier, the commercial elevators might still have a role to play in such situations, as they routinely are the grain brokers providing the bids and/or the trucking.

There has been interest in specialty or "non-commodity" type crops in Kansas in past years (e.g., white wheat, white corn, and high-oil corn). These crops may potentially have higher value than their "commodity" crop counterparts (i.e., red wheat, no. 2 yellow corn). However, preserving the identity of these crops is necessary to realize any higher value. Until production of these types of crops becomes fairly significant, preserving identity most likely will have to take place on the farm. Producers considering these higher-valued crops may be required to have on-farm storage facilities. In this case, part of the higher return of these crops is due to the crop itself, but part of it also should be viewed as a return to the on-farm storage facilities.

Another advantage of on-farm storage facilities is the potential for reduced bottlenecks associated with dumping at harvest. If producers have long distances to haul and/or have to wait in line at commercial elevators, on-farm storage may allow a more timely harvest. While quantifying this benefit is difficult, producers should consider how it affects their individual operations.

Historically, maintaining grain quality has been considered a disadvantage of on-farm storage. However, as automatic sensory equipment becomes more common, quality is less of an issue. It is illegal to add water directly to grain to add weight. However, the benefit of increasing moisture content through aeration or blending grain as a means of improving quality has been discussed in several popular press articles (e.g., Anderson; Henderson; Reichenberger). To the extent that this is possible, this aspect of on-farm storage could have considerable value for producers who sell grain that is "too dry," because premiums are not typically paid on dry grain. On the other hand, commercial elevators likely have superior grain blending capabilities, which might make off-farm storage more advantageous than on-farm storage for grain that is "too wet."

Producers who feed livestock should consider the advantage of having grain available when and where needed. In these cases, the return to on-farm storage facilities is often factored into the livestock enterprise. However, there is a benefit to having the storage facilities on-farm. Even if a producer buys all of his feed, as opposed to feeding his own grain production, on-farm storage facilities offer the benefit of market flexibility. The producer can buy feed from various sources at various times. Similar to truck bids, buying feed at harvest and storing may eliminate or reduce in/out charges, thereby reducing feed costs.

Another advantage of on-farm storage is that the variable storage cost will often be less than the cost of commercial storage, especially for grain stored for longer time periods. However, this is not an issue for producers who are considering constructing new on-farm storage facilities. In this case, all costs (fixed and variable) need to be considered. Also, all costs need to be covered if the storage facilities are to be replaced over time. Thus, while this lower variable cost characteristic is often thought of as an advantage, it is likely being over emphasized.

In some cases government subsidized loans may be available to producers for constructing storage facilities. Thus, this may give them a slight cost advantage over commercial facilities that face higher interest rates. To aid individuals interested in building on-farm storage, the USDA's Farm Service Agency (FSA) provides financial resources, up to $100,000, for qualifying individuals to construct and/or renovate non-commercial storage facilities through the Farm Storage Facility Loan Program. The loan must be approved by the local FSA county committee before any preparation or construction may begin. Eligible facilities included new conventional type cribs or bins; oxygen-limiting and other upright silo-type structures; flat-type storage structures; electrical and safety equipment; equipment to improve or maintain quality; and new concrete foundations. Renovations of existing farm storage facilities also may be considered for a loan if the useful life is at least 10 years. For more information about this loan program, please consult the "Farm Storage Facility Loan Program" fact sheet or contact your local FSA office.

While there are a number of advantages of on-farm storage producers need to consider, there also are some disadvantages:

- Producer is responsible for grain condition.
- Total cost may be greater than commercial storage costs.

- Producer assumes higher risk in maintaining grain quality and absorbing costs.
- Additional labor may be required to handle the grain.
- It might be more difficult to deal with landlord's grain.

An advantage of commercial storage is that once the grain is delivered, the producer does not need to worry about the grain condition. With commercial storage, producers are paid for the quality of the grain that is delivered into storage. With on-farm storage, producers are paid for the quality of grain taken out of storage. Therefore, it is important to recognize the management requirements associated with maintaining grain condition.

The total costs of on-farm storage may be greater than the cost of commercial storage. Large commercial elevators that specialize in grain storage would be expected to have a cost advantage. Producers who are considering on-farm storage will need to recognize benefits they would not realize with commercially stored grain. Without these "extra factors," on-farm storage generally will not be competitive with commercial storage.

In addition to costs being higher than with commercially stored grain, on-farm storage costs will be more variable. Commercial storage costs are basically known with certainty when the producer puts the grain into storage (with the exception of interest rate fluctuations). However, on-farm storage costs will vary depending on such factors as grain condition and repairs. From a cost standpoint, more risk is associated with on-farm storage. However, for good managers the cost variability likely is small.

With commercial storage, once the grain is delivered, no further labor is required from the producer. On-farm storage may require additional labor when the grain is hauled out. However, for operations that tend to under-use labor during some months, this may be an efficient way to use labor. For example, a crop producer without livestock may find that hauling grain in the winter is a good way to capture returns to storage if they place a low opportunity cost on their time.

On-farm storage of landlord's shares of grain in crop-share leases may introduce differences in opinions about when grain should be sold, questions about quantity immediately following harvest if the farmer lacks a scale, or frustrations on the tenant's part for having to provide "free" storage to the landlord. Of course, good communication between landlord and tenant often will alleviate the potential disadvantage. Moreover, in many cases, it is the landlord who is providing the grain storage facility and thus it could be the tenant who is getting "free" storage.

Additional On-Farm Storage Facility Considerations

A number of factors that ultimately affect the profitability of on-farm storage facilities are difficult to include in a budgeting framework. Grain handling and storage facilities require careful planning. Normally, storage capacity can be doubled without any major problems. However, tripling the storage capacity requires careful planning before construction of the first bin. Most producers want to expand their facilities over time, as capital becomes available, rather than borrowing large sums to construct a total system. Therefore, planning becomes all the more critical, as it is easier to change things on paper than after construction begins.

All systems have bottlenecks that limit the throughput of the operation. Grain handling and storage components are part of the overall harvesting system. The storage facilities should not create bottlenecks that cause less than optimum performance of the combine(s) or truck(s). It is important to recognize where some of the bottlenecks can occur during harvest and plan to minimize them. The following are nine common bottlenecks in the harvesting system:

1. Truck's inability to maneuver around storage equipment.
2. Mismatch of harvesting, trucking, and unloading systems.
3. Distance from the field to the storage site.
4. Auger movement and positioning between bins.
5. Lack of drying capacity or storage for high-moisture grain.
6. Lack of preventive maintenance.
7. Lack of adequate all-weather roads and driveways.
8. Lack of conveniences for weighing trucks across scales.
9. Inadequate temporary storage ahead of cleaner or dryer.

Each of these bottlenecks can be avoided. However, in many cases, poor planning can result in at least three or four being built into the system. Thus, the producer must either make additional investments to correct the problem or live with it. The following is a discussion of factors that can alleviate or prevent the bottlenecks.

Site Selection

There are three main components of site selection. The site must be accessible, have electricity, and be well drained.

Accessibility includes adequate entrances off county or state roads and space around the bins. A minimum of 40-foot access off of a main road is required. A square open area of ¼ to ½ acre is needed for trucks to be able to turn around without backing long distances. Semi trucks require a minimum turning radius of 55 feet or a diameter of 110 feet.

Electricity is the second requirement. Single-phase electricity generally limits the largest motor to 10 horsepower. This is normally adequate for most drying fans, but could limit the capacity of the handling equipment or high-temperature dryers (HT dryers). Three-phase electricity is preferred for high-volume facilities and those that are planning on incorporating HT dryers, electrically driven augers, or pneumatic conveyors. A phase converter, which converts single-phase to three-phase, may be used. Producers need to work with electrical suppliers to make sure the electrical distribution lines can carry the load, adequate lines are installed, and allowances are made for future expansion. It is recommended that power lines be at least 100 feet from the grain bins, with underground lines used to bring power into the sites.[7]

The site's physical attributes is the third factor to consider. Most on-farm storage facilities can be constructed on a site of 1 to 2 acres. The storage bins should be located at least 50 feet from any building, although 100 feet is desirable. Groundwater should be a minimum of 10 feet below surface, with 15 to 20 feet preferred. Most pits used with legs are in the ground 8 to 10 feet, with large capacity pits exceeding 15 feet. The surrounding area should drain away from the site, with diversions constructed if necessary. Sump pumps never work as well as planned because of lack of maintenance and plugging of drains.

Under no conditions should runoff from surrounding areas drain through the grain handling facility. The driveways and bin pads should be 12 inches higher than the surrounding terrain to minimize erosion or water problems into pits or bins. Another site factor to consider is nearby residences. Prevailing winds can carry chaff, foreign material, or debris toward residences. Fan noise also can be a problem if the fans are installed on the residence side of the bin. It is recommended that bins be located 200 feet from residences. A professional engineer may be needed for site preparation to ensure the soils will carry the dead loads created during storage.

Bin Selection

Each producer should determine how much storage is needed based on annual harvest, marketing potential, distance to elevator, and capital availability. The largest bin on the farm generally should not exceed 50 percent of the largest crop harvested. Multiple bins allow more flexibility than one large bin. Also, if a portion of the grain goes out of condition, the entire harvested crop is not jeopardized.

A minimum number of bins probably is one per crop per season. Therefore, someone who raises corn, grain sorghum, and soybeans should have at least three bins. As was demonstrated in Figure 4, larger bins normally have a lower initial investment, as compared to multiple smaller bins, but lack long-term flexibility. Bins used primarily for seed storage should be limited to 2,000 to 3,000 bushels per bin and preferably have a hopper bottom. For grain storage, bins continue to get larger, with 100,000 bushel and larger bins becoming more common. However, it is important to recognize the increased importance of managing the grain quality and condition in these large bins.

Drying Systems

Options available for in-bin drying systems include natural-air drying; low-temperature drying (LT); layer drying; batch-in-bin drying; dryeration; LT with recirculator, stirrers, or continuous flow drying. LT drying systems, as a minimum, require a full perforated floor, a fan capable of providing 0.75 cubic feet of air per minute (cfm) per bushel, and a burner unit. At

7 Minimum guidelines are outlined by the National Electrical Safety Codes for installation of power lines near grain bins and storage facilities.

least 25 to 50 percent of the total storage capacity should be equipped for low-temperature drying. Additional drying capacity can be obtained by installing a recirculator, stirrer or continuous flow drying system within a bin. Once storage capacity exceeds 50,000 bushels, installation of a HT dryer should be considered. Under no condition should a bin be constructed without having an aeration fan installed (only moves 0.1 to 0.5 cfm/bu as compared to 0.75 or greater cfm/bu with a drying fan). The sidewall depth should be limited to 16 feet or less if the bin is used for LT drying. The bins used strictly for storage can have deeper depths. Publication MWPS-13, Grain Drying, Handling and Storage Handbook, is a resource on various drying systems.

Bin Layout

Bin layout has two primary shapes: straight line or circular. Bins located in a straight line are easier to expand and incorporate into a vertical bucket elevator at a later date. The main disadvantage is with filling the bins with augers. Each time a bin is filled, an auger has to be moved. With increased auger capacities, a horizontal auger across the top of a row of bins enables an inclined auger to be set up once without having to move it each time a different bin is filled. Circularly arranged bins require careful planning. As the auger is rotated around a pivot point, it must be able to fill each bin. The auger is mounted such that the wheels rotate around the inside of bins and can be manually moved between bins. It is the opinion of the authors that straight-line bin arrangements are preferred to circular over the life of the system.

Other Considerations

Grain facilities are usually at one central site. Advantages to a central site include more efficient use of equipment, potential to automate equipment, less road construction and maintenance, more security, and central storage of records and grain quality equipment. However, some landlords may require their grain to be stored elsewhere, requiring multiple storage sites. Also, if the farm is ever sold, it may be easier to sell two smaller storage facilities than one large unit. For long-range planning, it is better to plan a central site and then subdivide at a later date, if necessary. It is often easier to downsize than to upsize the system.

Bins should have a minimum of 2 to 3 feet between them with 6 feet preferred if handling equipment must pass between bins. All mechanical systems eventually break down, accessibility or future repairs should be considered in the planning phase. The extra space between bins normally will not result in a noticeable difference in the cost of the handling equipment. The area around the bins should be treated to prevent grass and weeds from growing. Vegetation often serves as a home for rodents and insects and is difficult to maintain. Bins should have factory-installed ladders inside and outside, along with a man door and fill port. Other desirable accessories include roof vents (a must if fans are eventually to be automated), grain spreader, and temperature monitoring systems. Appropriate handling equipment for emptying the bin must be purchased and installed as the bin is erected.

Two rows of bins should be spaced a minimum of 20 feet apart. If a leg, dryer, scales, or feed processing center ever are installed, there is still adequate room for a driveway, along with these components. Roads should be crowned to provide adequate drainage for all-weather use. Planning bin layout should include consideration for the 110-foot diameter turning circle required by semi trucks.

Grain is handled on-farm with augers, bucket elevators (legs), or pneumatic conveyors. Once the capacity exceeds 100,000 bushels, a leg should be considered to provide flexibility in handling, blending, and turning of grain. High-temperature dryers should have smaller leg or auger arrangements to load and unload the dryer and not depend on the main grain handling equipment. Careful planning is required to make sure all of the components have at least equal capacity. As a planning guide, each time grain is transferred between handling equipment, the second piece of equipment should have a 10 to 25 percent higher capacity than the first. This will prevent bottlenecks within the grain handling system. The capacity of holding tanks ahead of a dryer or cleaner should equal 2 to 4 hours of combine harvesting capacity. Handling equipment can be eliminated if holding tanks are placed in the air and gravity feed.

The capacity of the handling equipment should be based on the desired truck unloading time. A 1,000-bushel truck unloading in 10 minutes requires the handling equipment to have a minimum capacity of 6,000 bushels per hour (bph). If a pit is used, then the unloading time is based on the expected time between loads received. Changing the unloading time from 10 to 15 minutes reduces the handling equipment capacity from 6,000 bph to 4,000 bph. A new facility using a bucket elevator should have a minimum capacity of 5,000 bph.

Summary

Increased crop production, specifically corn acres in response to ethanol production, coupled with steady to decreasing storage capacity in Kansas during the last half of the 1990s, has led to an increased interest in constructing on-farm grain storage. Farms operating with larger equipment and the trend toward identity-preserved crops have been factors in this increased interest in on-farm storage. An economic analysis of on-farm storage indicates that there are economies of size with regards to bin size or the size of an entire storage system. However, the costs of large bins or storage systems still likely will be higher than commercial storage costs. Thus, producers who consider constructing on-farm storage facilities will need to recognize benefits of storage other than simply taking advantage of seasonal price movements. These benefits, which could be either increased income or reduced costs, might come from such factors as identity preservation, reduced harvesting bottlenecks, and increased marketing flexibility.

A number of factors affecting the profitability of on-farm storage facilities are difficult to include in a budgeting framework, but these issues also need to be considered. For example, grain handling and storage facilities require careful consideration of current and future storage capacity as related to farm production and the size of harvesting and hauling equipment. Issues such as number and sizes of bins, site location, dryer capabilities, and weighing capabilities are important.

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Appendix – Figures of storage system layouts

Figure A1. *50,000 bushel system.*

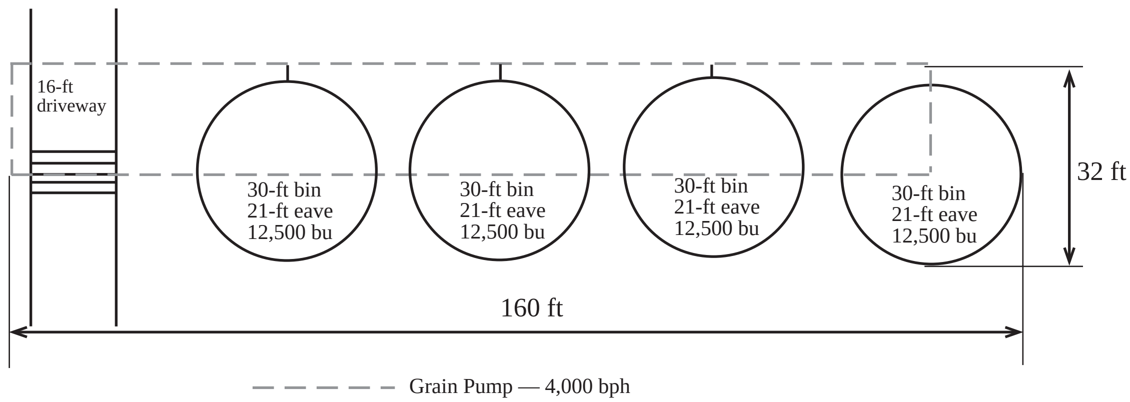


Figure A2. *95,000 bushel system.*

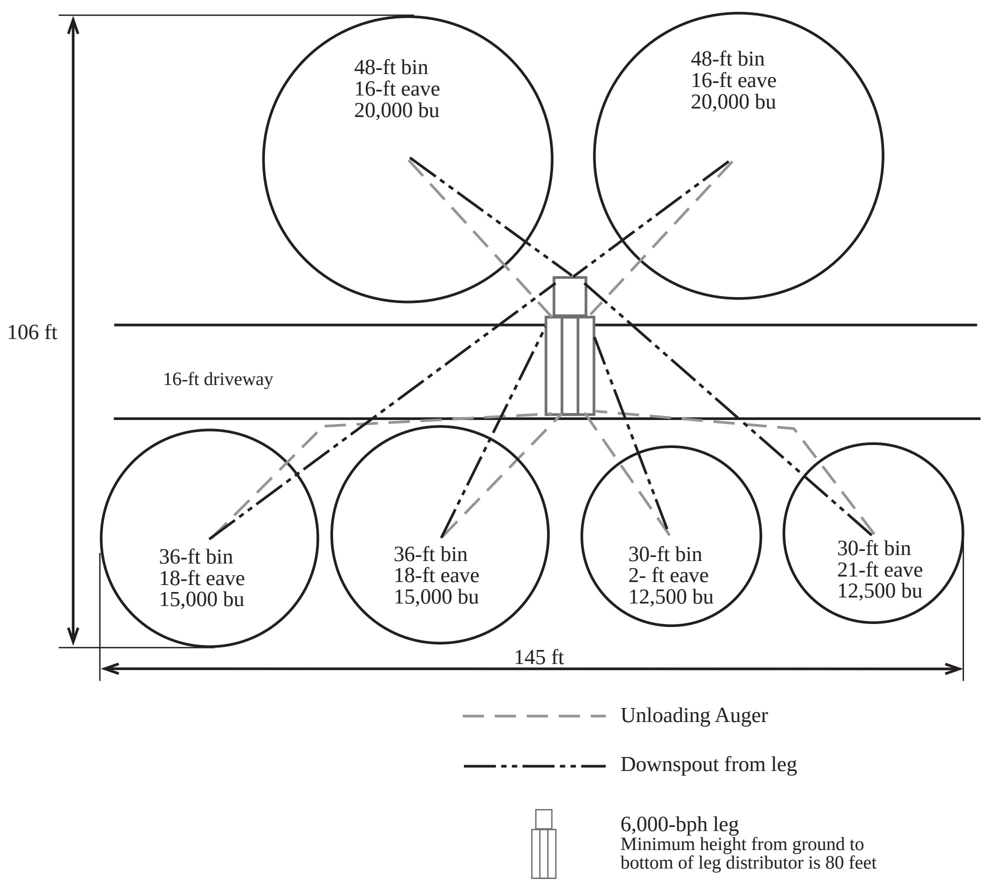


Figure A3. *163,100 bushel system.*

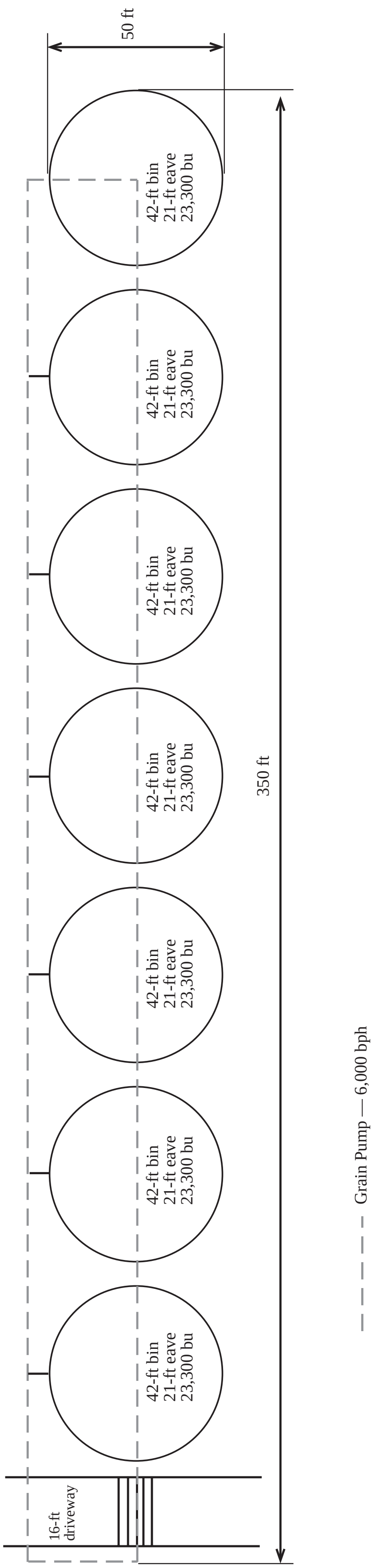
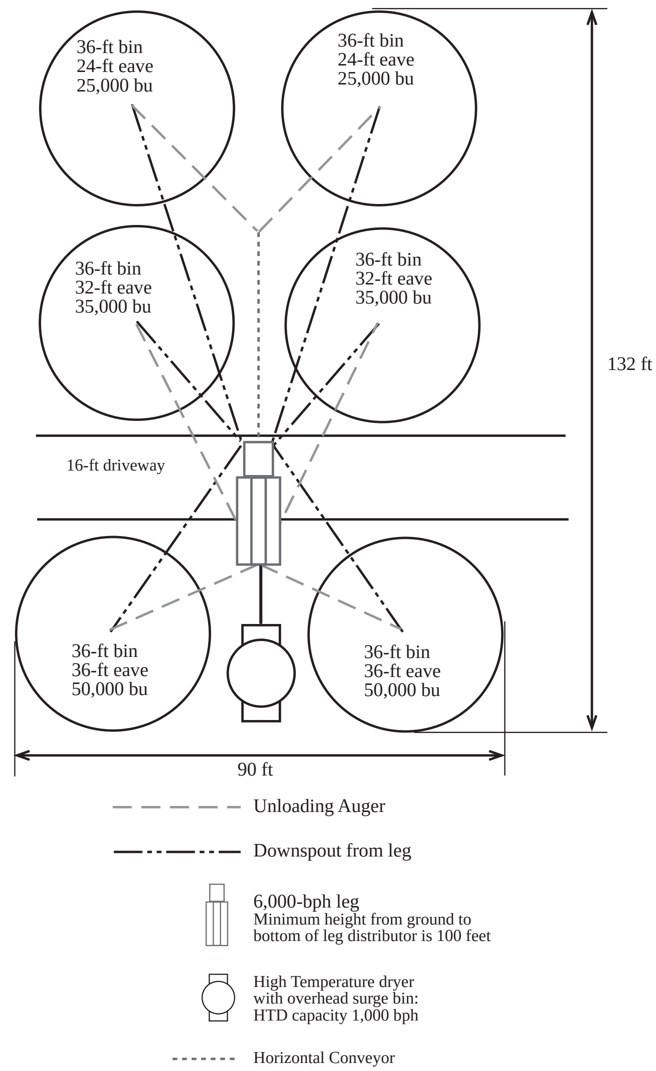


Figure A4. *220,000 bushel system.*



Your Storage Facility

Scale: 1 inch = ___________

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