A REVIEW AND COMPARISON OF IRRIGATION COST PARAMETERS

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A Review and Comparison of Irrigation Cost Parameters

The purpose of this report is to summarize the cost components which together determine the variable expenses associated with the operation of center pivot irrigation systems in Michigan.

Irrigation scheduling strategies will be evaluated in terms of yield potential with the CERES-Maize corn growth simulation model. The scheduling strategies will vary as to plant population, nitrogen fertilizer application rates, and the frequency and depth of irrigation applications. The outputs generated from CERES-Maize which will be used as inputs to the budget component of the analysis are listed below.

- Grain yield per acre
- Moisture content of the harvested grain
- Total seasonal water depth applied per acre
- Number of applications (or sets) per season
- Plant population
- Nitrogen application rule
- Nitrogen balance in the soil at the end of each growing season

Additional information generated by the model which may be useful in the decision analysis component of this study includes the following:

- Seasonal rainfall
- Planting date
- Soil characteristics
- Seasonal flux of nitrogen out of the root zone

Throughout this report, the use of CERES-Maize data in cost equations will be denoted with an asterisk (*). A summary of the recommended cost equations and the inputs required for their calculation is found at the end of this report.

A. ENERGY COSTS

Center pivot irrigation is highly energy intensive, and fuel and oil costs make up a major portion of a system's operating expenses. The amount of energy used by a center pivot system is dependent upon a number of factors, including pumping plant efficiency, pumping lift, system pressure requirements, and the amount of water pumped (per minute and annually).

Energy requirements are best estimated when a particular system's fuel consumption rate is known. System evaluations designed to determine the adequacy of irrigation water management for individual systems are frequently performed by the Soil Conservation Service (SCS) in an effort to demonstrate the potential for improved operational efficiency. Evaluations of this kind have been done in St. Joseph County, Michigan (USDA-SCS, 1984) and the results of these analyses will be used here to identify a set of default values which reflect the typical operating conditions and parameters facing the irrigators of that region. Listed below (Table 1) is a summary of those default values, as determined through the 1984 SCS evaluations, which are useful for an economic analysis.

Table 1. Irrigation System Evaluation Data Summary

	1st Quartile	Median	3rd Quartile
1. Acres Irrigated	39.0	98.7	134.4
2. Energy Use per Hour			
Electric (kWh/hr)	53.27	66.73	72.3
Diesel (gallons/hr)	3.14	4.11	5.60
3. System Capacity (GPM)	493	608	822
4. Application Efficiency (%)	81.1	95.1	98.2
5. Water Horsepower (WHP)	37.85	47.18	63.17
6. Pumping Plant Efficiency (%)			
Electric	48.7	53.7	63.4
Diesel	17.3	19.8	21.5
7. Pumping Depth (feet)	10	31	50

1. Annual Energy Costs

Given that the above information regarding system performance is available, annual energy costs are estimated in the following manner:

$$[1] \quad \text{ANNUAL ENERGY COSTS} = \text{ENERGY COST PER HOUR} \times \text{ANNUAL HOURS PUMPED}$$

a) Energy cost per hour -

Energy cost per hour is the cost of operating the pumping plant per hour, and is computed as:

$$[2] \quad \text{ENERGY COST PER HOUR} = \text{ENERGY USE PER HOUR} \times \text{FUEL PRICE}$$

where ENERGY USE PER HOUR is the energy consumption of the pumping plant for every hour of use (expressed as gallons/hour if the power source is diesel and kWh/hour if the power source is electric), and FUEL PRICE is the market price per unit of fuel used. ENERGY USE PER HOUR is determined by observing the fuel consumption of the pumping plant under normal operating conditions over a specified time period. Observed fuel consumption rates are then extrapolated to yield an hourly rate of energy use (as presented in Table 1).

b. Annual hours pumped -

Annual hours pumped is a measure of the pumping time required to apply a given quantity of irrigation water to a crop over an entire growing season. Pumping time depends on a number of factors, including system capacity (in gallons per minute), depth of irrigation water applied throughout the growing season (in acre-inches), application efficiency of the distribution system, and the size of the field being irrigated. The following equations are used to determine annual hours pumped.

$$[3] \quad \text{ACRE-INCHES PER HOUR PUMPED} = \frac{\text{SYSTEM CAPACITY (GPM)}}{453}$$

where ACRE-INCHES PER HOUR PUMPED is the capacity of the pumping plant expressed in acre-inches, and 453 is a factor which converts gallons per minute to acre-inches per hour.

$$[4] \quad \text{TOTAL SEASONAL WATER REQUIREMENT (ACRE-INCHES)} = \text{TOTAL DEPTH APPLIED PER ACRE *} \times \text{NO. OF ACRES IRRIGATED}$$

where TOTAL SEASONAL WATER REQUIREMENTS represents the quantity of irrigation water required by the crop over the entire acreage considered.

$$[5] \quad \text{TOTAL SEASONAL PUMPING REQUIREMENT (ACRE-INCHES)} = \frac{\text{TOTAL SEASONAL WATER REQUIREMENT}}{\text{APPLICATION EFFICIENCY}}$$

where TOTAL SEASONAL PUMPING REQUIREMENT is the total quantity of water pumped to meet the irrigation water requirement of the crop, assuming that a portion of the water pumped and distributed will not reach the crop surface. This loss is represented in the above equation by the APPLICATION EFFICIENCY term.

$$[6] \quad \text{ANNUAL PUMPING HOURS} = \frac{\text{TOTAL SEASONAL PUMPING REQUIREMENT}}{\text{ACRE-INCHES PER HOUR PUMPED}}$$

2. Annual Lubrication Costs

The annual cost of lubricant varies with the type of power source used to drive the pump and the degree of use during the growing season. The recommended approach is that developed by Kletke, et. al. (1978, p. 44), which uses the following equation to estimate the cost of oil for irrigation pumping plants:

$$[7] \quad \text{OIL COST PER ACRE-INCH} = \frac{\text{LUBRICANT MULTIPLIER} \times \text{WHP} \times \text{ANNUAL PUMPING HOURS} \times \text{OIL PRICE}}{\text{TOTAL SEASONAL PUMPING REQUIREMENT}}$$

where the LUBRICANT MULTIPLIER represents the rate of oil consumption for specific engine types, expressed as gallons of oil used per water horsepower hour (electric = .0005; diesel = .0015); WATER HORSEPOWER is a measure of the energy transmitted to the water by a pumping plant operating under a certain flow rate and total head; and OIL PRICE is the price per gallon of lubricant.

Kletke, et. al. 1978, p. 44) have also considered the cost of grease, which is calculated simply as a cost charged per hour of motor use.

[8] GREASE COST = \$0.02 x ANNUAL PUMPING HOURS

Brown and Skinner (1974, pp. 16-18) developed a similar approach to the estimation of lubrication costs. Their procedure involved the following equation:

$$[9] \quad \text{OIL COST PER ACRE PER APPLICATION} = \frac{\text{BHP} \times \text{HOURS PUMPING PER ACRE} \times \text{UNIT PRICE OF LUBRICANT}}{\text{BHP-HRS. PER UNIT OF FUEL}}$$

where BHP (brake horsepower) is the total power required by the pump; HOURS PUMPING PER ACRE is the time required for one complete system revolution at a given application rate; UNIT PRICE OF LUBRICANT is the cost of lubricant per gallon; and BHP-HRS. PER UNIT OF FUEL is the oil consumption rate of the specific engine type being used (electric = 9000; diesel = 900). This approach is not particularly suited to this analysis, given the procedures followed by SCS to determine pumping plant efficiency. Brown and Skinner base the above equation on brake horsepower (BHP), which is a measure of the size of the power plant (in horsepower) required to drive the pump. The pump output, defined as the work delivered to the water, is expressed as water horsepower (WHP) and is calculated in the following manner:

$$[10] \quad \text{WHP} = \frac{\text{SYSTEM CAPACITY (GPM)} \times \text{TOTAL DYNAMIC HEAD}}{3960}$$

where SYSTEM CAPACITY is the discharge flow rate of the pump; TOTAL DYNAMIC HEAD is a measure of the energy (expressed in feet) required by the pump to overcome the effects of fluid velocity, pressure differences, elevation, and friction loss; and 3960 is a coefficient to convert energy units.

Given the output work (WHP) of the pump, the input work required by the power plant (BHP) is:

$$[11] \quad BHP = \frac{WHP}{EFFICIENCY_{pump}}$$

where $EFFICIENCY_{pump}$ is a measure of the pump's ability to convert input energy (BHP) to output energy (WHP), expressed as a percentage of what is theoretically attainable. Pump efficiency varies between pump types, manufacturers, and models.

In contrast to this approach, the SCS measures efficiency as overall pumping plant efficiency, which takes into account not only the efficiency of the pump but also includes the efficiency of the power plant (1984, p. 13). Rather than use BHP, SCS calculations involve input horsepower (IHP), which represents the energy content of the fuel (in horsepower) being used by the power plant to drive the pump.

[12] ENERGY USE PER HOUR x CONVERSION FACTOR

where CONVERSION FACTOR converts fuel units to horsepower (diesel = 54.34; electric = 1.34).

Overall efficiency under this approach now incorporates the efficiency of both the pump and the power plant, and is calculated as:

$$[13] \quad EFFICIENCY_{overall} = \frac{WHP}{IHP}$$

Theoretical and typical operating efficiencies for pumping plants are shown in Table 2.

Table 2. Typical values of overall efficiency for for representative pumping plants, expressed as percent

Power source	Maximum theoretical	Recommended as acceptable	Average values from field tests#
Electric	72-77	65	45-55
Diesel	20-25	18	13-15

#Typical average observed values reported by pump efficiency test teams.
Source: Longenbaugh and Duke (1983, Table 10.4).

The efficiency standards used by the SCS in their evaluations are slightly higher than those recommended in Table 2 (electric = 67.5 %; diesel = 20 %).

B. REPAIR AND MAINTENANCE COSTS

Repair and maintenance costs are the most difficult component of the variable cost budget to accurately predict.

This is generally the case for all machinery, but is especially true for irrigation equipment due to a lack of available data and research. Among the factors which confound the estimating procedure include (a) management, (b) level of maintenance, (c) variation among identical machines, and (d) local costs for parts and labor. The problem is made even more difficult when one considers the variation in use between geographical regions, both in terms of operating conditions and intensity of use (Bowers, 1970, pp. 30-32).

Repair rates typically exhibit a slow, continual increase throughout the life of a machine. Therefore, annual repair and maintenance costs estimates should theoretically reflect both the age of the machine and the degree of use during the year as it relates to the machines's useful life. An approach to the estimation of repair and maintenance costs for agricultural machinery which most closely adheres to this theoretical ideal was developed by Bowers (1970) and has been approved by the American Society of Agricultural Engineers (1977) and modified by Baquet (1982). This approach allows for the estimation of accumulated repair costs at any point in a machine's useful life. The equation used is:

$$[14] \quad TAR = RC1 \times RC2 \times (\text{PERCENT LIFE})^{RC3}$$

where TAR is the total accumulated repairs; RC1 is the ratio of total accumulated repairs to the initial list price of the machine; RC2 and RC3 are repair coefficients estimated from actual machinery cost records that go together to determine the shape of the machinery repair rate curve; and PERCENT LIFE is the accumulated hours of machine use divided by the total hours of life of the machine (Baquet, 1982). Unfortunately, repair rate curves have not been developed for irrigation equipment, thus making this particular approach useless for the purpose of this analysis.

Because of the variability in expected useful life among the different components of a center pivot irrigation system, each component should be treated separately. This approach was used by Kletke, et. al. to estimate repair and maintenance costs for irrigation systems in Oklahoma. Though the operating conditions do differ between Oklahoma and Michigan, especially in terms of the intensity of annual use, these equations do represent the best available information and will be used in this analysis. The appropriateness of these equations can later be evaluated once several runs have been made.

1. Pump repair and maintenance costs

Both the expected useful life and the repair and maintenance costs for pumps vary with the degree of annual use. Longenbough and Duke (1983, p. 386) have estimated the useful life of various pump components on the basis of annual use, as is shown in Table 3. Because of the supplemental nature of irrigation in Michigan, pumping requirements usually range from 500 to 800 hours of operation annually.

Table 3. Estimated useful life (years) of various pump components

	Annual hours of use			
	500	1000	2000	3000
Well	25	25	25	25
Pump	15	15	15	10
Gearhead	15	15	15	10
Drive shaft	15	15	7	5
Engine	15	15	10	7
Gas line	25	25	25	25
Engine foundation	25	25	25	25
Electric motors	25	25	25	25
Electric controls and wiring	25	25	25	25

Source: Longenbaugh and Duke (1983, Table 10.3).

Kletke, et. al. (1978, p. 44) have estimated the annual repair costs for a pump in the following manner:

$$[15]\quad \text{PUMP REPAIRS PER ACRE-INCH} = \frac{.5 \times \text{TOTAL INVESTMENT IN PUMP} \times \text{ANNUAL PUMPING HOURS}}{30{,}000 \times \text{TOTAL SEASONAL PUMPING REQMNTS.}}$$

where 30,000 represents the estimated useful life of the pump in hours.

This approach does not differentiate between pump types, which may have an impact on repair and maintenance costs over the life of a pump. Most pumps used for irrigation are a form of the centrifugal pump. Horizontal centrifugal pumps are typically used for surface and shallow well pumping. Deeper wells often require the use of vertical-type centrifugal pumps, usually referred to as deep well turbine pumps. These differ from the horizontal types in that they contain a submersible portion referred to as the bowl assembly, which houses one or more impellers. The bowl assembly accounts for approximately 50 percent of the total cost of the deep well turbine pump, though it has one-half of the useful life. The SCS (1959, p. 66) has suggested that throughout the useful life of a given pump, annual repair and maintenance costs be estimated as:

$$[16] \quad \text{TURBINE} = \frac{\text{1/2 TOTAL COST}}{\text{ESTIMATED LIFE IN YEARS}}$$

$$[17] \quad \text{CENTRIFUGAL} = \frac{\text{TOTAL COST}}{\text{ESTIMATED LIFE IN YEARS}}$$

These estimates do not, however, consider any variation in the degree of use from year to year. Therefore, until better estimates are made available, Kletke's approach is recommended for this analysis.

2. Motor repair and maintenance costs

Kletke, et. al. (1978, p. 45) have developed the following procedure for estimating annual repair costs for the engines which drive the pump:

$$[18] \quad \text{MOTOR REPAIRS PER ACRE-INCH} = \frac{\text{MOTOR REPAIR MULTIPLIER} \times \text{ANNUAL PUMPING HOURS} \times \text{COST OF ENGINE}}{\text{TOTAL SEASONAL PUMPING REQUIREMENT}}$$

where the MOTOR REPAIR MULTIPLIER specifies the repairs per hour per dollar of engine purchase price for the type of engine being used (electric = .00001; diesel = .0001).

3. Distribution system repair and maintenance costs

Repair cost for a self-propelled (i.e. center pivot) system is calculated in a manner similar to Kletke, et. al. (1978, p. 45):

$$[19] \quad \text{DISTRIBUTION REPAIR COSTS PER ACRE-INCH} = \frac{\text{REPAIRS PER DOLLAR OF LATERAL VALUE PER YEAR} \times \text{TOTAL COST OF LATERALS} \times \text{ANNUAL PUMPING HOURS}}{30{,}000 \times \text{TOTAL SEASONAL PUMPING REQUIREMENTS}}$$

where 30,000 is the useful life in operating hours of the distribution system, and REPAIRS PER DOLLAR OF LATERAL VALUE PER YEAR is estimated as 0.05 for self propelled systems. This equation deviates from Kletke, et. al. in that the degree of annual use (represented by ANNUAL PUMPING HOURS) is considered.

Given the equations presented above, the total repair and maintenance costs for the entire irrigation system is determined by adding the cost estimates of each separate component (pump, motor, and distribution system). Again, it is important to point out that these figures are but an estimate of the repair costs likely to occur under average operating conditions.

C. LABOR COSTS

Labor requirements and costs vary among irrigation systems. Center pivot system labor requirements are small when compared to other systems due to the continuous movement design. The calculation of labor costs involves primarily the start-up and shut-down time plus any attendance time which may be necessary.

The recommended approach is that of Kletke, et. al. (1978, pp.45-46), who have allocated labor requirements and costs between the pump motor and the distribution system.

1. Motor labor costs

$$[20]\quad \text{LABOR COST PER ACRE-INCH ON MOTOR} = \frac{\text{ENGINE LABOR MULTIPLIER} \times \text{ANNUAL PUMPING HOURS} \times \text{LABOR WAGE RATE}}{\text{TOTAL SEASONAL PUMPING REQUIREMENTS}}$$

where the ENGINE LABOR MULTIPLIER represents the labor required per hour for engines of specific fuel types (electric = .03; diesel = .06), and LABOR WAGE RATE is the wage rate in dollars per hour.

2. Distribution system labor costs

The labor requirements for the distribution system depend not only on the total quantity of water applied per acre but also on the depth of water applied each application (or set).

$$[21]\ \text{DISTRIBUTION LABOR COST PER ACRE-INCH} = \frac{\text{ACRES IRRIGATED PER YEAR} \times \text{DISTRIBUTION SYSTEM LABOR FACTOR} \times \text{LABOR WAGE RATE} \times \text{TOTAL DEPTH PUMPED PER ACRE}}{\text{TOTAL SEASONAL PUMPING REQUIREMENT} \times \text{DEPTH PUMPED PER SET}}$$

where the DISTRIBUTION SYSTEM LABOR FACTOR represents the hours of distribution labor required per acre per set for a specific system (self propelled system = .06); TOTAL DEPTH PUMPED PER ACRE is the depth of water pumped per acre over the entire growing season; and DEPTH PUMPED PER SET is the quantity of water pumped during each irrigation application (i.e. the pre-determined irrigation strategy).

$$[22]\ \text{DEPTH PUMPED PER SET} = \frac{\text{DEPTH APPLIED PER SET*}}{\text{APPLICATION EFFICIENCY}}$$

$$[23]\ \text{DEPTH PUMPED PER ACRE} = \frac{\text{DEPTH APPLIED PER ACRE*}}{\text{APPLICATION EFFICIENCY}}$$

Upon examining equation [21], one should notice that the terms ACRES IRRIGATED PER YEAR, TOTAL DEPTH PUMPED PER ACRE, and TOTAL SEASONAL PUMPING REQUIREMENT will cancel out. However, they have been left in the equation to make clear the fact that the labor cost has been calculated on an acre-inch basis.

Other approaches to the estimation of labor requirements and costs tend to lump the pump and distribution system activities into one term. Pair (1975, p. 467) has suggested that the labor requirements for a center pivot system are between 0.05 and 0.3 hours per acre per irrigation.

$$[24] \quad \text{CENTER PIVOT LABOR COST} = \text{LABOR REQUIREMENT} \times \text{LABOR WAGE RATE}$$

where LABOR REQUIREMENT is the above mentioned estimate of labor required in hours per acre per irrigation.

Brown and Skinner (1974, p. 16) estimated the labor requirement for center pivot systems to be 0.011 hours per acre per irrigation, and labor costs to be:

$$[25] \quad \text{CENTER PIVOT LABOR COST} = 0.011 \times \text{LABOR WAGE RATE}$$

The decision to use the Kletke, et. al. is based on the fact that by estimating labor costs for the pumping plant and distribution system separately, differences in labor requirements among different types of engines are accounted for, thus providing an estimate which is sensitive to individual system characteristics.

D. ADDITIONAL PRODUCTION COSTS

Irrigation also involves the increase in other variable production costs which are not directly related to the quantity of water applied or the hours of operation accumulated during the growing season. Those variable cost components which are indirectly affected by the decision to irrigate include (a) plant populations, (b) fertilizer applications, (c) drying charges, and

(d) transportation and freight costs.

Production cost estimates for Michigan are published periodically by the Department of Agricultural Economics at MSU (Nott, et. al., 1984), and cost comparisons are made for different levels of irrigation management and expected yield goals. Cultural practices commonly followed by Michigan irrigators can also be determined by contacting county extension agents.

1. Plant population

Plant populations are typically increased by 4000 to 8000 plants per acre in Michigan when irrigation is used to supplement corn production. The following approach will be used in estimating this expense:

$$[26] \quad \text{COST OF SEED PER ACRE} = \frac{\text{PLANT POPULATION *}}{.85} \times \frac{\text{50\# BAG OF SEED}}{\text{80,000 SEEDS}} \times \text{COST OF SEED PER POUND}$$

where COST OF SEED PER ACRE is the cost of seed under irrigation; PLANT POPULATION is the plant population planned under irrigated conditions; and .85 reflects the fact that approximately 15% more seed must be planted per acre to achieve a specific plant population (Finner and Straub, 1985, p. 201).

2. Fertilizer applications

The increased application of fertilizer, specifically nitrogen, phosphorus, and potassium (potash), usually accompanies irrigation. While nitrogen is the only nutrient whose effects can be modeled by CERES-Maize, additional inputs of phosphorus and potassium should be assumed in the analysis. Common application rates and costs per pound are provided in the MSU crop budget publication (Nott, et. al, 1984, pp. 12-13).

The estimated fertilizer costs resulting from irrigation are calculated as follows:

[27] COST OF NITROGEN PER ACRE = NITROGEN APPLIED PER ACRE* x PRICE PER POUND OF NITROGEN FERTILIZER

[28] COST OF PHOSPHORUS PER ACRE = PHOSPHORUS APPLIED PER ACRE x PRICE PER POUND OF PHOSPHORUS FERTILIZER

[29] COST OF POTASH PER ACRE = POTASH APPLIED PER ACRE x PRICE PER POUND OF POTASH FERTILIZER

3. Drying charges

Additional drying charges will be realized as a result of the higher yields produced through irrigation. CERES-Maize output can be modified to reflect the moisture content of the grain at harvest, and the additional drying necessary to bring the moisture content down to 15.5% will be determined. The MSU crop budget publication calculates drying charges on the basis of an assumed moisture content at harvest (27.5%) and a specific cost per point removed. Drying charges in this analysis will be calculated in this manner with the following equation:

$$[30]\quad \text{DRYING CHARGE PER ACRE} = \text{YIELD PER ACRE*} \times \text{\% MOISTURE REMOVED*} \times \text{PRICE PER POINT REMOVED}$$

where % MOISTURE REMOVED is the difference between the moisture content of the grain at harvest and 15.5%; and PRICE PER POINT REMOVED is the cost charged to remove each percentage point of moisture.

4. Transportation and freight costs

The cost of harvesting and hauling the additional yield produced with irrigation must also be considered. This cost is calculated on the basis of the yield realized with irrigation.

$$[31]\quad \text{FREIGHT COSTS PER ACRE} = \text{YIELD PER ACRE*} \times \text{DISTANCE HAULED} \times \text{PRICE PER BUSHEL HAULED}$$

where PRICE PER BUSHEL HAULED is the price charged per bushel per mile to transport the grain; and DISTANCE HAULED is the distance (in miles) from producer to buyer.

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SUMMARY OF EQUATIONS AND INPUTS

ENERGY COSTS

1. Fuel Costs

Input Data:

CERES-Maize
- Total Depth Applied per Acre

Default Values
- Energy Use per Hour
- Number of Acres Irrigated
- System Capacity (GPM)
- Application Efficiency (%)
- Fuel Price

[1] ANNUAL ENERGY COSTS = ENERGY COST PER HOUR x ANNUAL HOURS PUMPED

[6] ENERGY COST PER HOUR = ENERGY USE PER HOUR x FUEL PRICE

[2] $\text{ANNUAL PUMPING HOURS} = \dfrac{\text{TOTAL SEASONAL PUMPING REQ.}}{\text{ACRE-INCHES PER HOUR PUMPED}}$

[3] $\text{ACRE-INCHES PER HOUR PUMPED} = \dfrac{\text{SYSTEM CAPACITY (GPM)}}{453}$

[4] TOTAL SEASONAL WATER REQ. = TOTAL DEPTH APPLIED PER ACRE x NUMBER OF ACRES IRRIGATED

[5] $\text{TOTAL SEASONAL PUMPING REQ.} = \dfrac{\text{TOTAL SEASONAL WATER REQ.}}{\text{APPLICATION EFFICIENCY}}$

2. Lubrication Costs

Input Data:

Default Values
- Water Horsepower (WHP)
- Oil Price

Previously Used Values
- Annual Pumping Hours
- Total Seasonal Pumping Req.

[7] $\text{OIL COST PER ACRE-INCH} = \dfrac{\text{LUBRICANT MULTIPLIER} \times \text{WHP} \times \text{ANNUAL PUMPING HOURS} \times \text{OIL PRICE}}{\text{TOTAL SEASONAL PUMPING REQUIREMENT}}$

[8] GREASE COST = $0.02 x ANNUAL PUMPING HOURS

REPAIR AND MAINTENANCE COSTS

Input Data:

Default Values
- Total Investment in Pump
- Total Cost of Engine
- Total Cost of Laterals

Previously Used Values
- Total Seasonal Pumping Req.
- Annual Pumping Hours

[15] PUMP REPAIRS PER ACRE-INCH = (.5 x TOTAL INVESTMENT IN PUMP x ANNUAL PUMPING HOURS) / (30,000 x TOTAL SEASONAL PUMPING REQUIREMENTS)

[18] MOTOR REPAIRS PER ACRE-INCH = (MOTOR REPAIR MULTIPLIER x ANNUAL PUMPING HOURS x COST OF ENGINE) / (TOTAL SEASONAL PUMPING REQUIREMENTS)

[19] DISTRIBUTION REPAIR COSTS PER ACRE-INCH = (REPAIRS PER DOLLAR OF LATERAL VALUE PER YEAR x TOTAL COST OF LATERALS x ANNUAL PUMPING HOURS) / (30,000 x TOTAL SEASONAL PUMPING REQUIREMENTS)

LABOR COSTS

Input Data:

CERES-Maize
- Depth Applied per Set
- Total Depth Applied per Acre

Default Values
- Labor Wage Rate

Previously Used Values
- Annual Pumping Hours
- Total Seasonal Pumping Req.
- Number of Acres Irrigated
- Application Efficiency

[20] LABOR COST PER ACRE-INCH ON MOTOR = (ENGINE LABOR MULTIPLIER x ANNUAL PUMPING HOURS x LABOR WAGE RATE) / (TOTAL SEASONAL PUMPING REQUIREMENTS)

[21] DISTRIBUTION LABOR COST PER ACRE-INCH = (ACRES IRRIGATED PER YEAR x DISTRIBUTION SYSTEM LABOR FACTOR x WAGE RATE x TOTAL DEPTH PUMPED PER ACRE) / (TOTAL SEASONAL PUMPING REQUIREMENT x DEPTH PUMPED PER SET)

[22] DEPTH PUMPED PER SET = (DEPTH APPLIED PER SET) / (APPLICATION EFFICIENCY)

[23] DEPTH PUMPED PER ACRE = (DEPTH APPLIED PER ACRE) / (APPLICATION EFFICIENCY)

ADDITIONAL PRODUCTION COSTS

Input Data:

CERES-Maize
- Plant Population
- Nitrogen Applied per Acre
- Yield per Acre
- Moisture Content of Final Yield

Default Values
- Cost of Seed per Pound
- Cost of Nitrogen per Pound
- Phosphorus Applied per Acre
- Cost of Phosphorus per Pound
- Potash Applied per Acre
- Cost of Potash per Pound
- Price per Point Removed
- Price per Bushel Hauled
- Distance Hauled

[26] COST OF SEED PER ACRE = (PLANT POPULATION / .85) x (50# BAG OF SEED / 80,000 SEEDS) x COST OF SEED PER POUND

[27] COST OF NITROGEN PER ACRE = NITROGEN APPLIED PER ACRE x PRICE PER POUND OF NITROGEN FERTILIZER

[28] COST OF PHOSPHORUS PER ACRE = PHOSPHORUS APPLIED PER ACRE x PRICE PER POUND OF PHOSPHORUS FERTILIZER

[29] COST OF POTASH = POTASH APPLIED PER ACRE x PRICE PER POUND OF POTASH FERTILIZER

[30] DRYING CHARGE PER ACRE = YIELD PER ACRE x % MOISTURE REMOVED x PRICE PER POINT REMOVED

[31] FREIGHT COSTS PER ACRE = YIELD PER ACRE x DISTANCE HAULED x PRICE PER BUSHEL HAULED