Hillside Golf Course Sidney, Nebraska Irrigation System Assessment 100% Submittal

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Irrigation System Evaluation

This evaluation was conducted to review the existing irrigation system at the 18 hole Hillside Golf Course. Brian Keighin, Principal from Irrigation Technologies was on site October 12-13,2011 to examine the current irrigation system, and operational practices.

Executive Summary

The irrigation system is a predominately Toro brand, two row valve in head system with fairway head spacing averaging 75'-80' while green head spacing (50'-100+') is more varied. The heads are the 670 model and are no longer in production with parts availability for this model limited.

The control system that activates the sprinklers is a series of Hunter field controllers. Each controller acts independent of one another. There is no central computer to optimize the operation of the field controllers. The golf course would realize an enormous benefit in terms of operational efficiency and reduced energy costs with the addition of a central computer system.

Some of the heads are single head control, but many of stations control two, and in many cases three sprinklers on a station. Single head control is the preferred method to control golf irrigation heads. Single head control maximizes the performance of the sprinkler and provides the golf course superintendent the highest level of control, and ability to condition the golf course. A sprinkler head performance test was conducted during the site visit at the putting green near 10 tees. The performance of the heads measured 41%, well into the 'Poor' category.

The mainline and lateral pipe infrastructure is the polyvinyl chloride (PVC) and asbestos cement (AC). PVC typically has a 15 year service life span before operators begin to see failures. The AC pipe can have a service life of 50-70 years, but is a hazardous material and is best left undisturbed. Removal of the AC pipe is expensive due to its hazardous material/ waste classification. AC pipe is no longer used in golf course irrigation systems and PVC is no longer the favored material. High density polyethylene (HDPE) is the favored pipe material for new golf course irrigation systems.

The irrigation system has one (1) pumping station located just east of 3 fairway. It is a Watertronics centrifugal lift pump station installed in the spring of 2003. The pumping capacity of the station is 750 gallons per minute (GPM) at a discharge pressure of 125 pounds per square inch (psi). The pump station is fitted with one (1) 7.5hp pressure sustain pump, one (1) 40 hp pump and one (1) 60hp pump. Pump testing on the 40 and 60 hp pumps was completed during the data collection process.

The golf course does not have any useable construction record drawing also referred to as an as-built to assist with the operation of the system. An as-built would be very helpful in the operation of the system and would improve labor efficiency associated with the operation of the system.

The course has (1) one water source available that is delivered via an underground pipe that is delivered by The City of Sidney to the irrigation reservoir adjacent to the pumping station near 3 fairway. Based on a 3 year average the golf course consumes 171.49 acre feet of water per irrigation season.

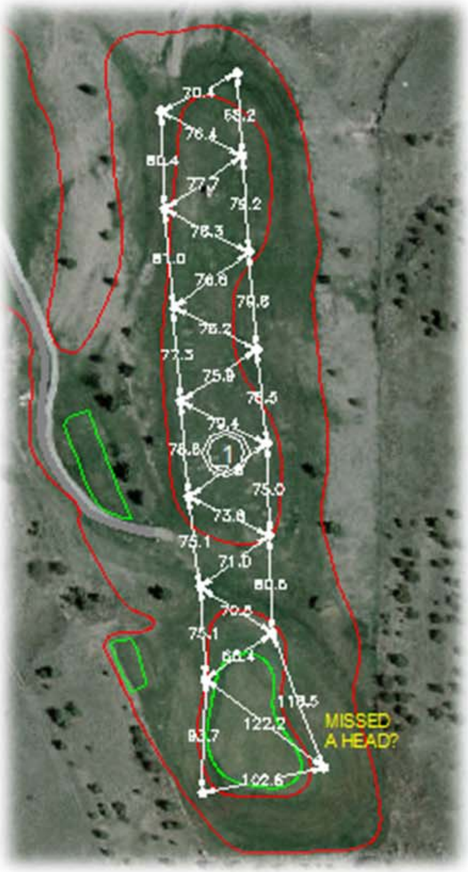


Illustration. 1 Typical head spacing (1 Fairway)

Illustration.2 Head spacing at PG by 10 Tees complex

A. *Sprinkler Heads*

The majority of the sprinkler heads are the original installed equipment, Toro 670 full circle heads. The heads are spaced throughout the golf course at about 75-80’ in most areas (see illustration. 1). There are some areas, such as greens that the head spacing exceeds the typical spacing on the rest of the course (see illustration 2). Ideal spacing for this sprinkler head is 75’. This head will attain the highest level of distribution uniformity (DU) when spaced at a uniform 75’ spacing. Distribution uniformity is a measure of how uniform the sprinkler distributes water across its radius of throw. The DU value is expressed as a percentage, the higher the DU, the more uniform the application of water. A typical lab test DU for a head spaced at 80' is 77%, whereas a head spaced at 65' with the same pressure setting has a lab test DU of 92%. Field test DU's of 80%-85% are easily attainable with new heads spaced at 65'. Areas that have heads “stretched” can be identified by having thin turf density, and require additional hand/spot watering. The Center for Irrigation Technology (CIT), an independent test facility associated with California State University, Fresno, tests all types irrigation equipment and identifies the performance of sprinkler heads at specific flow rates, spacing and pressures. This information is provided to irrigation designers and can be referenced during the design process.

The same holds true performance wise, for heads that are spaced too closely together. As shown in illustration 2, some of these heads are spaced 50.2'. Heads designed to throw 75' spaced this close together will always leave a wet area.

As the system has aged, and sprinkler heads have begun to fail, new heads have been installed. The original 670 heads are no longer manufactured by Toro, and repair parts are limited. The old heads are being replaced by Toro 850 series heads. The new 850 series heads are a good direction to go and will allow the system to perform at an improved performance level. The new heads will perform at a slightly higher performance level than the original equipment simply due to the improved distribution uniformity (DU) of the nozzle. However, it is important to consider the orientation of the new heads. Heads perform best when set level, and at grade. This allows the nozzle stream to distribute water in a uniform manner, and achieve a high DU. A level sprinkler will minimizes any stream blockage from ground interference. An inventory needs to be taken to identify heads that are in poor, failing condition and should be replaced as capital dollars allow. It is cost prohibitive to properly adjust the spacing of the installed equipment unless the entire area and/or hole is changed. Varied spacing can only be corrected by installing new heads at the proper spacing. This requires a new irrigation system.

Picture 1. Catch Can Testing on PG by 10 tees

During the overnight irrigation cycle on October 12,2011 catch cans were placed on the putting green near 10 tees. The purpose was to identify the DU of the existing heads. The irrigation system was set to operate a regular cycle. Forty-one (41) catch cans were placed on the green surface. The collected volume of water was recorded into an irrigation schedule worksheet along with the soil type, average root depth, and plant species. The collected volume identified an application rate of 0.71" per hour and a DU of 41%. The 41% DU rates well into the poor category. The poor category is identified by a DU of less than 55%. New equipment at a tighter uniform spacing, pressure, and flow can yield a field test DU of 80-85%. There is an exceptional opportunity for sprinkler performance improvement at Hillside Golf Course.

Pressure plays a big part in the sprinkler performance as well. Without adequate pressure, the equipment cannot perform as designed. During the data collection process (illustration 3), three (3) pressure data loggers were placed on the golf course during an overnight irrigation cycle. One logger was located at 6 green (green line), one at the pump station (blue line), and one at 9 green (red line).

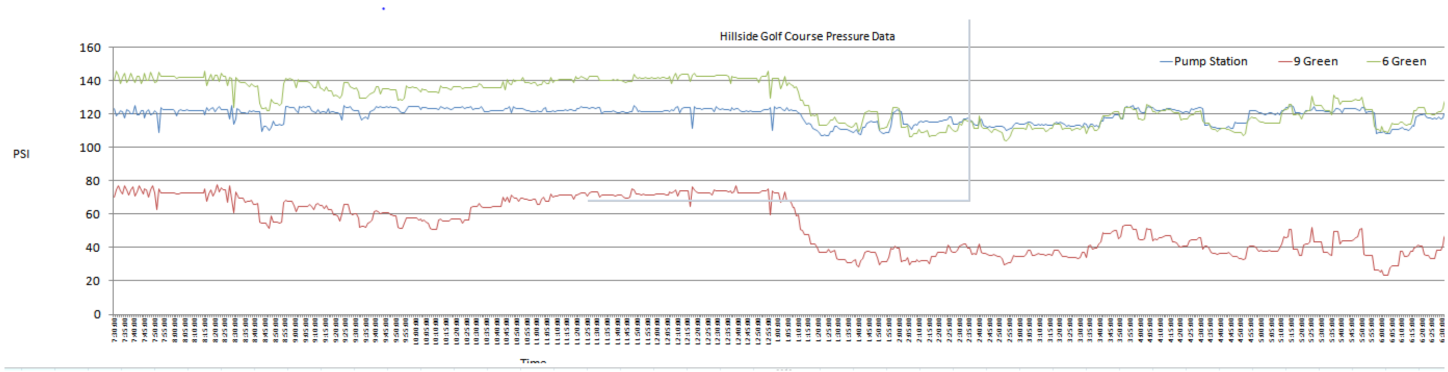


Illustration 3. Data from 3 pressure monitoring devices (full size graph in appendices)

The saw tooth pattern seen at the beginning of the graph indicates that the pumps are turning on/off with regular frequency. This is a sign of a "loose" system, one that has several leaks and/or weeping heads. In fact, while setting up test equipment in the pump station, it was noted that the pressure maintenance pump was cycling on and off every 40 seconds. It is important to note, that a new system will see pump cycling every 60 minutes on average. The next component of the graph begins around 8:30pm and coincides with the start of the overnight irrigation cycle. A slight dip in pressure on the all three lines indicates that the field controllers are turning on more heads than the pipe network can supply. The pressure appears to rebound around 9:00pm and the station is able to provide adequate flow until 1:00am. The pressure again drops significantly on all three lines from 1:00am until 4:00am. Again, the most likely cause of the pressure drop would be the field controllers activating more heads than the pipe network can supply, and during certain periods of irrigation, more flow than the pump station is able to produce and maintain the 125 psi set point. The graph indicates that the pressure at 9 green can vary from the high 70 psi range to a low of 23.4 psi at 6:03am during the irrigation cycle. The pump station cannot supply adequate pressure to the areas that have similar elevation to that of 9 green. A pressure model was built to identify the static pressure at each tee, fairway, and green. The lowest static pressure occurs on #1 tee, estimated at 72.6 psi, and the highest static pressure occurs at 5 green, 137.6 psi. This model does not take into account the friction loss that occurs as the water moves through the pipe, but additional pressure loss occurs during the irrigation cycle. The loss is directly proportional to the velocity of the water, the higher the velocity, the greater the pressure loss. A central computer would provide a flow management system that would reduce the pressure swings identified in illustration 3.

B. ***Field Controllers, Central Control and Weather Station***

Picture 2. Hunter Irrigation Satellite

The irrigation system is controlled by a group of field controllers, commonly referred to as satellites. The Hunter brand irrigation satellites are the gray colored pedestals located throughout the course. This satellite, (picture 1) is several generations behind the current Hunter offering. Each satellite controls a group of heads within relative close proximity to the satellite. Each satellite operates independently of one another at Hillside. It is very common on most golf course irrigation systems for each satellite to communicate via radio or hardwire to a central computer. The central computer coordinates the irrigation cycle, allows the superintendent the ability to apply a specific amount of water to a specific area, and maximizes the efficiency of the pump station thereby reducing power consumption and utility cost. Based on the information collected during the site visit and the observed 12 hour irrigation cycle, a central control system has the potential to reduce the water window by a minimum of 2-3 hours, a 20-25% reduction. The city will realize a similar reduction in the kWh used at the pump station to power the pumps. Hillside golf course should consider installing a new control system that includes central control capability. An budget cost for a new central control system is $125-150K. A new control system can be designed as phase one of a new irrigation system, and will return immediate and noticeable results in terms of turf quality and operational costs.

Another control system component that is lacking at Hillside is a weather station. A weather station is used to monitor and log environmental conditions (wind, temperature, solar radiation) and determine the daily Evapotranspirtion Rate (E.T.) of the turf grass. E.T. is a measurement of the water that is lost through evaporation and plant transpiration. The ET value is used by the superintendent to develop a watering schedule to replace the water loss since the last irrigation cycle. The central computer database has defined precipitation values for each sprinkler and if the daily ET calculated from the weather station was a 0.18", the superintendent can develop an irrigation cycle that will match the 0.18" loss. The weather station can be configured to allow other City of Sidney sites access to the weather data for irrigation run time adjustments. A weather station can easily pay for itself within one season just by the realized water and energy savings. A budget cost for a weather station is $11,000-$15,000 for hardware/software and installation.

Picture 3 &4. Typical Weather Station & 2" Pipe Repair

C. ***Mainline & Lateral Pipe Infrastructure***

The pipe infrastructure at Hillside is composed predominately of PVC pipe. The club is experiencing an average number of repairs to the pipe infrastructure. The majority of repairs are needed on the 2" lateral network (picture 4).

PVC has been the most commonly used pipe material in golf irrigation applications for many years and has an average service life of 15-20 years. PVC is available in many different classes and schedules depending on the application and pressure requirement. Irrigation systems of similar age typically have Class 200 (CL200) PVC while front end budget conscious courses opted for CL160 PVC. The study was not able to identify the class of PVC pipe that is in the ground at Hillside. There is also some asbestos cement (AC) pipe in the ground at Hillside. AC pipe was a predecessor to PVC. It is considered a hazardous material and should be left undisturbed. Any necessary repairs to this pipe should be made by a firm that is experienced in handling and disposal of the waste material generated during a repair.

Current golf irrigation technology employs the use of High Density Polyethylene Pipe (HDPE) for the mainline and lateral pipe infrastructure. The advantages of an HDPE system over PVC include; constant working pressure rating, higher cyclic resistance to material failure, freeze resistance, monolithic pipe construction, improved ability to "snake" the pipe through a free form trench alignment, thrust blocking not typically required, high level of impact/scar resistance that is beneficial during vibratory plow installation, and perhaps most important the manufacture of the product is environmentally friendly compared to PVC. The new irrigation system piping infrastructure will benefit for years with the use of HDPE pipe and is highly recommended.

D. <u>Pumping Station</u>

The irrigation system has one (1) pumping station located just east of 3 fairway. It is a Watertronics centrifugal lift pump station installed in the spring of 2003. The pumping capacity of the station is 750 gallons per minute (GPM) at a discharge pressure of 125 pounds per square inch (psi). The pump station is fitted with one (1) 7.5hp pressure sustain pump, one (1) 40 hp pump and one (1) 60hp pump. Pump testing on the 40 and 60 hp pumps was completed during the data collection process. The pump testing identified the flow performance for each pump, the amount of energy required to operate the pump and a pump plant efficiency value. The pumping plant efficiency value is calculated by multiplying the motor efficiency (noted on the motor) by the pump efficiency, (determined by flow testing). A typical 40-60 horsepower motor will have an efficiency rating in the low ninety's as is the case with the two motors on the station. The efficiency(chart 1) for pump 1 is 49.4% and rates as a poor performer as defined by the Center for Irrigation Technology (CIT). Pump 2 tested as 43.3% efficient. The centrifugal lift station is an inefficient method to pump water. Centrifugal pumps are typically range in the 60-65% efficient neighborhood whereas a vertical turbine pump is typically 80-85% efficient. There is a great opportunity for Hillside to realize operational savings and improved pump performance with a vertical turbine pump station. The existing wet well is 20' deep and can easily accommodate a two vertical turbine pumps.

The pump station is performing as designed but is not providing the needed pressure for holes near the clubhouse. The static pressure model has identified that hole 9, 10, 18, driving range and putting green area does not have adequate pressure for the sprinkler heads to perform as designed. Two solutions are available, install a booster pump to supply adequate pressure to those areas, or move the pump station to a location that will supply adequate pressure to the holes 9, 10, 18 and the driving range complex.


Picture 5 & 6 Main Pump Station Interior and Pump Station Building

Pumping System	Motor Efficiency	Pump Efficiency	System Efficiency
Pump #1 (40 HP)	91.7%	53.8%	49.4% = Low Rating
Pump #2 (60 HP)	93.0%	46.6%	43.4% = Low Rating

Chart 1. Pump Station Efficiency Ratings

The pump station is sized to apply 0.22" of water to the 83 acres of irrigated turf in 11 hours. A typical irrigation water window is 8-10 hours. If the current irrigation cycle is impacting course maintenance and play Hillside should consider replacing the pump station with one that has greater capacity. To reduce the water window to 8 hours with a 0.25" application would require a pump station with a 1,200 GPM capacity. An estimated budget for a 1,200GPM pump station is $110-135K.

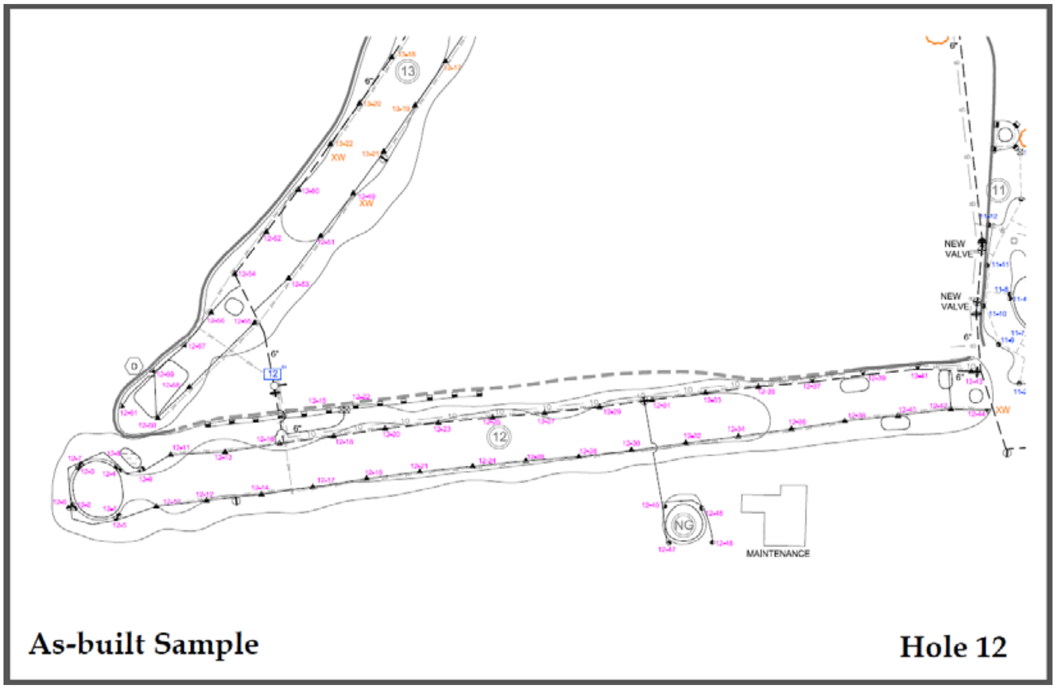


Illustration 4. Sample As-is of One Hole

E. Record Drawings and Field Documents

Hillside does not have any documents that identify the irrigation equipment. A good As-built or in the case of Hillside, As-Is document can greatly improve the superintendents ability to manage the irrigation system. The document provides at a glance the sprinkler head type, location, station assignment, and area of coverage. When decides to move forward with the implementation of a new irrigation system, an As-Is document would prove invaluable in the installation of the new system and operation of the existing system. A sample of an As-Is hole sheet is included in the appendix of the report. To generate a good As-Is document is $5K-$7K.

Picture 7. Irrigation Pond After a Heavy Irrigation Cycle (400K Gallons)

F. ***Water Source, Location and Capacity***

The existing pond adjacent to the pump station on hole 3 supplies the water for the irrigation system. The surface area of the pond is 26,014 square feet, about 0.60 surface acres. The pond is relatively small in terms of surface area, but fairly deep at approximately 20'. There is adequate water storage capacity to meet the needs of the golf course, but during heavy irrigation cycles, the drawdown of the pond is significant. This can cause bank erosion as well as be aesthetically distracting. Water is supplied to the pond via off site city well and transferred through an underground pipeline. The transfer line is operated by The City of Sidney.

G. ***Appendix Additional Pictures and Larger Size Graphs***

Pump Efficiency Hydraulic and Cost Data

Pump Location/Description		**Pump Make:**	Watertronics
Hillside Golf Course Pump 1		**Pump Model Number:**	
Customer Contact Name		**Type:**	Centrifigual Suction Lift
Mr. Kris Johnson Superintendent		**Well Depth:**	20' 3"
Customer Address		**Well Diameter:**	48"
2616 Hillside Drive Sidney Nebraska, 69162			

Motor Name Plate Information

Customer Phone:	(308) 254-7100	**Motor Make:**	Baldor
Customer Fax:		**Motor Serial or Model Number:**	JNN25387
Customer Cell:	(308) 254-7100	**Motor Voltage:**	460
Customer Email:	kaj-53@hotmail.com	**Motor Amps: (FLA)**	45
		Name Plate RPM:	3500
Motor Horse Power:	40	**Motor Efficiency:**	91.7%
Utility Company:	City of Sidney	**Power Factor: (%)**	91%
Meter Number:	29 464 987	**Hours/Starts:**	17868 hours/ starts not listed
Test Date:	10/13/2011	**Tester:**	Irrigation Technologies

Hydraulic Results		**Hydraulic Test Result Formulas**
Inlet Pressure: (Feet)	**0**	For Booster Application - Negative Number for Suction Lift
Discharge Pressure (PSI):	**127**	2.31 ft = 1 P.S.I.
Standing Water Level (Feet):		Water Level while *NOT* Pumping
Draw Down (Feet):	**0**	Difference in Standing Water and Pumping Water Level
Pumping Water Level (Feet):	**0**	Water Level while Pumping
Total Head (Feet):	**293**	Discharge Head plus Pumping Water Level
Measured Flow Rate (GPM):	**320**	Using any additional method of finding flow rate
Customer Flow Rate (GPM):	**320**	Customer Meter flow rate
Gallons pumped in 24 Hours:	**460,800**	GPM x 60 x 24
Acre/Feet pumped in 24 Hours:	**1.41**	(GPM x 60 x 24)/(325,851)
Cubic Feet per Second (CFS):	**0.71**	GPM/448.8
kW Input to Motor:	**35.8**	On-site Utility Meter, Wattmeter, or Volt & Amp Meters
Actual Power Factor	**0.866**	
HP Input to Motor:	**48.0**	kW input x 1.341
Water HP	**23.7**	(GPM x Total Head) / 3960
Motor Load (%):	**110%**	HP Input x Motor Eff / Name Plate HP
Measured Speed of Pump, RPI	**3500**	Use RPM Gauge if available

Cost Results		
Cost per Hour ($/Hour):	**$1.79**	KW Input x Kwh Cost
Cost to Pump a Million Gallons:	**$93.23**	((1,000,000/GPM)/60 min) x Cost Per Hour
Cost per Acre/Foot:	**$30.39**	(.326) x Cost to Pump Million Gallons
Base Cost per Kwh(estimated):	**$0.05**	See Utility Bill
Overall Plant Efficiency (%):	***49.4%***	(Water HP/Input HP) x 100
		Note additional loads

Additional Test Findings and Formulas Used:

Input kW (Electric Meter Timing = Number of Meter Revolutions x 3.6 x Disk Constant x Meter Multiplier / Time in Seconds for Meter Revolutions

Disk Constant = The "kh" value on meter face **Meter Multiplier** = The "MULT" value on meter face

Pump Efficiency Hydraulic and Cost Data

Pump Location/Description		**Pump Make:**	Watertronics
Hillside Golf Course Pump 2		**Pump Model Number:**	
Customer Contact Name		**Type:**	Centrifigual Suction Lift
Mr. Kris Johnson			
Superintendent		**Well Depth:**	20' 3"
Customer Address		**Well Diameter:**	48"
2616 Hillside Drive			
Sidney Nebraska, 69162			
		Motor Name Plate Information	
Customer Phone:	(308) 254-7100	**Motor Make:**	Baldor
Customer Fax:		**Motor Serial or Model Number:**	JMM2546T
Customer Cell:	(308) 254-7100	**Motor Voltage:**	460
Customer Email:	kaj-53@hotmail.com	**Motor Amps: (FLA)**	68
		Name Plate RPM:	3500
Motor Horse Power:	60	**Motor Efficiency:**	93.0%
Utility Company:	City of Sidney	**Power Factor: (%)**	89%
Meter Number:	29 464 987	**Hours/Starts:**	15427 hours/ starts not listed
Test Date:	10/13/2011	**Tester:**	Irrigation Technologies

Hydraulic Results		**Hydraulic Test Result Formulas**
Inlet Pressure: (Feet)	**0**	For Booster Application - Negative Number for Suction Lift
Discharge Pressure (PSI):	**127**	2.31 ft = 1 P.S.I.
Standing Water Level (Feet):		Water Level while *NOT* Pumping
Draw Down (Feet):	**0**	Difference in Standing Water and Pumping Water Level
Pumping Water Level (Feet):	**0**	Water Level while Pumping
Total Head (Feet):	**293**	Discharge Head plus Pumping Water Level
Measured Flow Rate (GPM):	**440**	Using any additional method of finding flow rate
Customer Flow Rate (GPM):	**440**	Customer Meter flow rate
Gallons pumped in 24 Hours:	**633,600**	GPM x 60 x 24
Acre/Feet pumped in 24 Hours:	**1.94**	(GPM x 60 x 24)/(325,851)
Cubic Feet per Second (CFS):	**0.98**	GPM/448.8
kW Input to Motor:	**56.2**	On-site Utility Meter, Wattmeter, or Volt & Amp Meters
Actual Power Factor	**0.856**	
HP Input to Motor:	**75.4**	kW input x 1.341
Water HP	**32.6**	(GPM x Total Head) / 3960
Motor Load (%):	**117%**	HP Input x Motor Eff / Name Plate HP
Measured Speed of Pump, RPI	**3500**	Use RPM Gauge if available

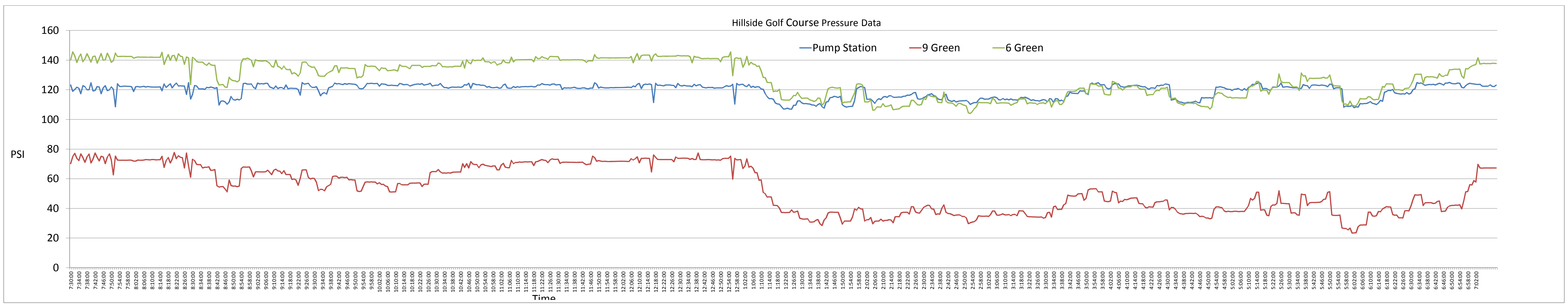
Cost Results		
Cost per Hour ($/Hour):	**$2.81**	KW Input x Kwh Cost
Cost to Pump a Million Gallons:	**$106.44**	((1,000,000/GPM)/60 min) x Cost Per Hour
Cost per Acre/Foot:	**$34.70**	(.326) x Cost to Pump Million Gallons
Base Cost per Kwh(estimated):	**$0.05**	See Utility Bill
Overall Plant Efficiency (%):	***43.3%***	(Water HP/Input HP) x 100
		Note additional loads

Additional Test Findings and Formulas Used:

Input kW (Electric Meter Timing = $\frac{\text{Number of Meter Revolutions x 3.6 x Disk Constant x Meter Multiplier}}{\text{Time in Seconds for Meter Revolutions}}$

Disk Constant = The "kh" value on meter face

Meter Multiplier = The "MULT" value on meter face


Hillside Golf Course Pressure Data
Pump Station
9 Green
6 Green
PSI
160
140
120
100
80
60
40
20
0
Time

2 Hole Head Layout @ 65' head spacing

- 11 acres of irrigated area on holes 12 & 13
- 182 heads shown
- 16 heads per acre needed
- Estimate $1,300/head $20,800/acre, $1,726,400 for 83 acres for an irrigation system similar to that shown

Hillside Golf Course
Sidney, Nebraska

SHEET Ir-1 OF 1

SHEET TITLE: Preliminary Head Layout

REVISIONS

Project	Hillside GC
Drafter	BDK
Check	BDK
Plot Date:	12-12-11
Scale:	1" = 150.0'

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