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October 10, 2013

The Golf Course

Dear Bill,

Thank you for the opportunity to provide The Golf Course with our golf course water auditing services. The evaluation and testing phase was performed on October 2nd &3rd. The audit included distribution uniformity analysis, testing hydraulic pressures and evaluating the system during the day and during the nightly irrigation cycle. In this report you will find detailed facts about the different irrigation components. We include pictures, pressure charts and the results from the catch can and spacing profiles. We begin with an executive summary and conclude with our recommendations.

Executive Summary

The main line irrigation pipe, fittings and valves are forty years old. Approximately 90% of the 4" and higher pipe is asbestos. Asbestos is considered a hazardous material by CalOsha and regulations require specialized contractors to repair and remove it. The lateral pipes are undersized and on parts of the course, not of adequate thickness for golf course irrigation systems. Failure of fittings and pipe is occurring at an increasing annual rate. The other system components including sprinklers, satellites and wiring are no less than seventeen years old. Many of the sprinklers and satellite parts have reached their life expectancy or are almost there. There are numerous sprinklers broken and leaking around the entire course. The leaking sprinklers and piping are causing the pumps to constantly cycle on and off. There is a low pressure problem on holes 1-8. Water pressure on hole #5 is the lowest on the golf course. It is apparent that the low pressure problem is on all of the holes downstream of the pressure regulating valve on #10 fairway. The expenses for water, power, labor and irrigation repair parts continue to annually rise. In some cases it makes economic sense to only retrofit or change one or two of the key components of an irrigation system. Given the age and condition of everything except the pump station, the most cost effective option for Lake Wildwood is to plan for and install a new irrigation system. For detailed information please refer to the following sections on each irrigation component.

Central Computer / Programming & Field Data

The computer and software are from the Rain Bird Company. The computer functions slowly but it has been operating well and communicating to the field satellites consistently. The programming of the Nimbus software was performed prior to 2005. The hydraulic flow tree was programmed to accommodate all of the individual lateral pipe lines across the entire course. This is the ideal way to program hydraulic flow zones, but given the fact that there are 1-4 sprinklers on each station, the flow zones can't be turned down to limit flow on any lateral zone. This is the case on most of the stations. The only way to limit the flows across the golf course is to adjust the main line gallons per minute. During our time on site, we adjusted several flow zones and main irrigation lines down in gallons to see if this will help increase pressures on the golf course. In addition, we adjusted some flow up in gallons to eliminate error messages in the Nimbus software.

Hydraulic System

Main line pipe

Approximately 90% of the main irrigation line is made of asbestos. This type of pipe was used on a regular basis on golf course and municipal water delivery lines up until the early 1980's. Today PVC or HDPE pipe are used exclusively for golf irrigation systems. The use of asbestos was stopped when it became evident that asbestos fibers could lead to lung cancer. Today the Division of Occupational Safety and Health (DOSH) enforce all regulations regarding employee safety, including asbestos related work sites. Any persons working with asbestos must follow a list of practices to ensure their safety. In addition, employers must report any anticipated operation or process involving asbestos to DOSH. Given that the asbestos piping at Lake Wildwood has occasional breaks that require handling and repair, this puts employee health at risk and creates the potential for future lawsuits. We advise that hazardous materials type suits and masks be used by staff that comes into contact with asbestos.

On holes four and thirteen the main lines were retrofitted in order to create a looped main line to improve system flow and pressure. Pressure improved but the 4" PVC that was used in the process has broken several times for unknown reasons. Furthermore; without calculating the hydraulic effects of these additions, there is no way to know what effect they have on water flow and friction loss. Both are important factors that have a direct correlation to system integrity and longevity.

PVC main line cracked and replaced

Lateral Pipe Lines

The lateral irrigation pipes connect to the main irrigation line and deliver water to 6-12 sprinklers on a given lateral. The lateral piping connects to the main line with the use of a range of PVC fittings. These fittings are breaking at an alarming rate. Maintenance has been documenting most breaks in the system and reports the following numbers of breaks and labor hours for repair.

2012 -----	**18+ breaks requiring, 180 labor hours for repair**
2013 -----	**20+ thru August 30th, requiring 112 labor hours for repair**

Further investigation revealed that these breaks have been common for several years and the frequency and severity worsen every year. While on site, we observed staff devoting many hours looking for a break in a lateral pipe on #17 fairway. (See picture below)

PVC pipe break on #17 fairway
Water leaking into the drain pipe directly below

#17 fairway – searching for leak in lateral pipe

The lateral pipes are mostly 1 ½" PVC. This size pipe was probably chosen solely as a cost saving measure when it was installed in 1984. Typically 2"-2.5" is now commonly used. These sizes allow higher flows with less pressure loss while sprinklers are running. Based on acceptable velocity of flow and friction loss, the laterals should have no more than 35 gallons per minute (GPM) flowing in a lateral. This equates to running one sprinkler at a time. Based on our observation, when two sprinklers came on at the same time on one lateral, pressure dropped 10-15 PSI. Sprinkler performance was visually and measurably negatively affected. Evidence of undersized pipe and a limited # of laterals, can be found on tees 2 & 3. No more than one station can be run at the same time without a severe pressure drop. Another problem discovered with the laterals is that some of it is class 160. Class 60 is a thinner wall pipe compared to schedule 40 with a higher pressure rating. Many of the breaks have occurred in the class 160 pipe.

Some of the numerous remains from failing fittings and sections of pipe

Pump Station

The pump station appears to be the only component of the irrigation system that does not need to be replaced. It is well maintained and looks in excellent condition. Despite being 17 years old, it has state of the art Flowtronex control panels and variable frequency drive pumps. There are a quantity of three 75 horsepower (HP) and one 30HP pumps. It also has a small pressure maintenance pump designed to keep the system up to pressure. Although staff operates the system at 1800 gallons per minute (GPM), it has the capability of producing well over 2000 GPM at 125PSI. A pump efficiency test was performed in recent years but the resulting data was inconclusive due to a flawed test. This type of test is used to create a performance base line. Data and annual testing can help determine the life expectancy of the pumps.

The Pump Station on hole #12

Pump Flow Compared to Projected Flow

There is a difference in the amount of gallons actually being pumped and the amount of gallons projected to run in the central irrigation computer. We recorded the gallons pumped and compared the difference.

		Gallons at Pump	Gallons at central	Difference	%
October 2,	7:48PM	1925-1984	1800	125-184	**10% higher at pump**

It is an industry standard that flow at the pumps is within 5% of the central. Currently flow at the pump station is 10% higher than projected in the central computer. As the percentage increases, it is likely that low pressure can be the result. It is always preferred that if there is a difference, you would rather have the central projecting higher than actual. As to the specific cause of the higher gallons, there are several possibilities;

- Worn nozzles on the sprinklers
- Nozzles have been changed and distributing more gallons (see sprinklers for more detail)
- Leaking sprinklers and leaking hydraulic lines

In an effort to determine why there is a difference we performed a simple test. We turned on five sprinklers of the same type. While they were running, we looked at the flow meter display in the pump station. (Test presumes accuracy of flow meter). On the 700 series full circle sprinklers, the average was approximately 30

GPM. In the central computer, the 700 series are listed at 22.6 gallons. The 750 part circle sprinklers are listed as 20.2. On a similar test of the 750 sprinklers, the flow at the pump meter averaged 32 gallons per sprinkler. It is evident that all sprinklers are distributing more water than listed in the central. Based on this data, we would expect the total gallons to be much higher over the course of a nightly irrigation cycle. We know that there are low pressure problems on holes 1-8 and nozzle flow is less than listed in the data base. Thus the higher nozzle flows on the rest of the golf course is neutralized by the lower gallons used at lower pressures. (Please refer to "Pressure Recording" for more details).

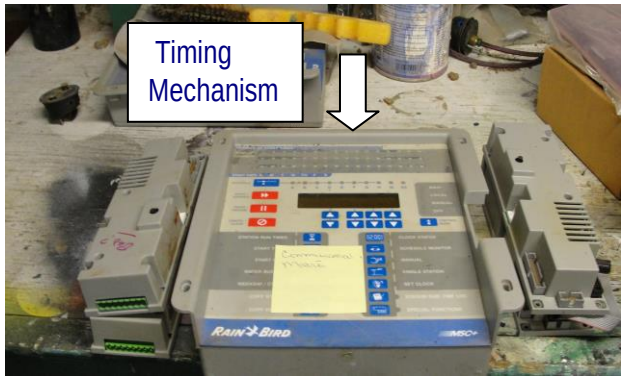
Main line gate valves

The main line gate valves used to isolate the system in case of a break are leaking and not dependable. When they need to be closed and opened, there is always the question as to whether or not the valve will break or just not work. Over the past few years, five have needed replacement.

Irrigation Satellites

The Rain Bird satellites were installed during the partial irrigation renovations in 1995. They replaced older electro-mechanical clocks that had become unreliable. At the time, station wires were not added in order to separate stations with 2-4 sprinklers. Stations with multiple sprinklers do not provide the same amount of irrigation control as individual sprinkler head control. There are 78 satellites on the golf course. The satellites are operable and communicate to the Rain Bird central computer. The most common problem is the failure of the 8 station modules and the timing mechanisms. The modules fail at a rate of 10-12 annually. When these parts fail, the result is usually dry turf and inconsistent conditions. We also saw a couple of satellites with holes or cracks in the plastic exteriors.

Holes in the Rain Bird cabinet

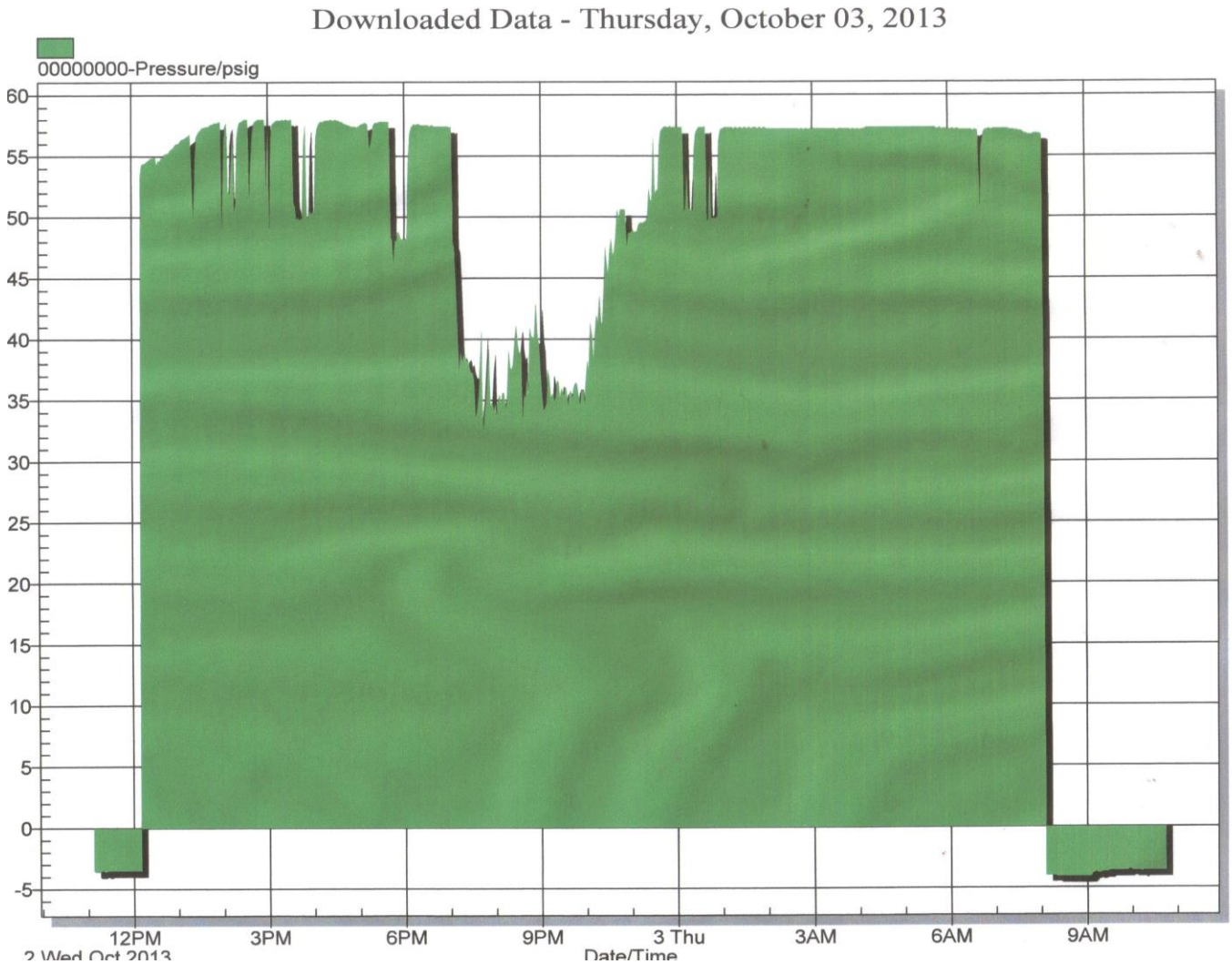


Failed 8 station modules and timing mechanisms

Wire tracking and repair

Pressure Recording on Main Hydraulic Line

Main line pressure was recorded on #5 fairway from 12:10 PM October 2- 8:30 AM, October 3rd. (Refer to chart on next page). The low section in the middle is the time during the nightly irrigation cycle. The pressure in that area was never above 58PSI. The lowest pressure was 32PSI and the average was 42PSI. The Rain Bird sprinklers are regulated to have pressure out of the nozzles be around 65PSI. At the current main line pressures there is no regulation. Sprinklers with lower pressures do not have the same radius of throw as they should in order to achieve the desired sprinkler to sprinkler water distribution. The water droplets become larger and tend to create more wet areas in the pattern of the sprinkler. The low pressure has become a worsening problem over the last few years. It is the main reason why it is difficult to maintain consistent turf on the affected holes.

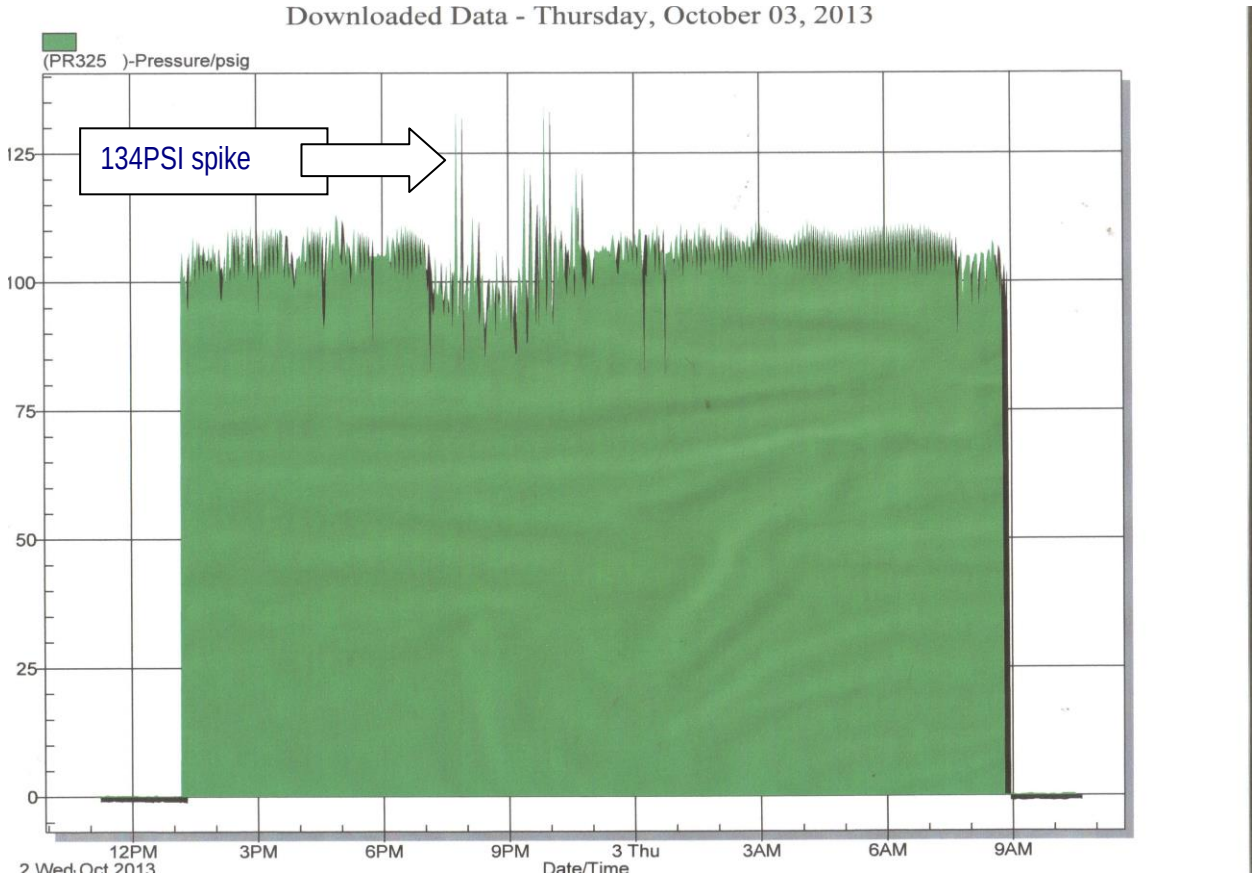


Pressure Recording from #5 Green – October 2, 2013

Pressure Recording from #13 Green

A second pressure recorder was placed on the main line on green #13. (See chart below) The pressure at this area was much better than the front nine. During the nightly cycle, pressure averaged 101PSI. The graph showed a low of 83PSI. The chart below reveals several spikes where pressure reached 134PSI. It is difficult to determine why these spikes occurred. A look into the central programming and timing of stations revealed no clues as to why there were spikes. The high spikes and up and down nature of pressures cause wear and tear in hydraulic systems due to water hammer. The chart also shows that there is constant cycling of the smaller pressure maintenance (PM) pump and the 30 HP jockey pump. Every six minutes one of the pumps was activating to keep the hydraulic system pressurized. This was evident even during periods where no water was running. Leaking piping and sprinklers are most likely the cause of the cycling.

NOTE: It should be pointed out that in pressure tests conducted in 2008, pressure on #5 green was low and averaged about 60-65PSI. At #3 green it averaged 80-85PSI. Of the four pressure charts we viewed from 2008, all of the pressures averaged higher compared to the tests on October 2, 2013.



Pressure Recorded on #13 Green October 2, 2013

Pressure Regulating Valve (PRV)

There is one PRV on the main line and it's located on #10 fairway. Static pressure was recorded during the day on both sides of the PRV. The pressure upstream of the PRV at #10 green was 119PSI. On the downstream side at the putting green, the pressure was 91PSI. The PRV is operating correctly and is maintained on a regular basis. It is unknown as to why the outgoing pressure downstream is set to 90PSI. The holes downstream of the PRV include 1-9 & the driving range. Given that these same holes had low pressure during the nightly irrigation cycle and during the day, an increase in PRV pressure should be considered. (Please see short term recommendations and sprinkler pressures for details)

Sprinklers

Age & Condition

The majority of sprinklers are 17 years old. There is a significant amount of leaking sprinklers that are creating wet and muddy soil around them. (See pictures below). During the two days on site, we activated, observed or tested at least 80 sprinklers around the course. Of the 80 sprinklers, at least 15 were leaking or had some problem with the nozzle or cap. Based on the amount of sprinklers on the golf course, we estimate that over 260 sprinklers are failing and in need of replacement. Over the years nozzles have been changed in order to customize the distribution of water based on spacing and coverage. These changes in the field are not reflected in the central database. This can be one of the reasons that the pump station flow does not match the central database.

Wet & muddy around 700 sprinkler

Leaking 700 sprinkler on #13

Leaking Rain Bird 700 full circle sprinkler

Green flag above marks leaking sprinkler

Broken seal on 700

Leaking 750 at night

Catch Can Test for Distribution Uniformity (D.U.)

(Refer to following pages to view test charts)

Defining Distribution Uniformity

D.U. is a measure of how evenly water is made available to plants over a given area. If four inches of water is applied into the ground in one part of the field and only two inches into another part of the field that is poor distribution uniformity. Distribution uniformity is expressed as a percentage between 0 and 100%. Although 100% distribution uniformity is theoretically possible, it is virtually impossible to attain in actual practice. A new irrigation system is expected to test between 80-85%. Good distribution uniformity is critical for maintaining consistent conditions across the entire golf course. The lower the D.U. the more water that is

required to keep turf adequately irrigated. According to the Irrigation Association the percent D.U. in relationship to performance can be summarized by the following;

D.U. in percentage	Performance
80%	Excellent
70%	Good
55%	Poor

Note: *It is our opinion that a DU of 60% or below is poor and a DU of 65% is poor to fair at best.*

At The Golf Course we performed five tests on four different areas. The average D.U. from the five catch can tests at Lake Wildwood was 70.6%. This puts the Distribution Uniformity into the "Good" range. #1 fairway tested the worst at 59% and the best was #15 fairway at 75%. The areas and sprinklers tested can be found on the charts following this page. The individual test results
were as follows;

- #1 Fairway 59%
- #13 Fairway 73%
- #15 Fairway 75%
- # 5 Fairway 74% (daytime)
- # 5 Fairway 72% (night time)

Data Interpretation

Catch can tests are one of many tools used to determine the efficiency and effectiveness of an irrigation system. They are a measurement at one point in time in a given area. Catch can tests should never be the sole reason for renovating an irrigation system. Likewise, they should not be a reason to continue working with an older costly system.

Catch can test on #1 Fairway

Sprinkler Spacing

We took a GPS reading of every sprinkler on #12 fairway and rough from the start of the fairway to the lake edge. With the data we calculated spacing in feet to within +/- 1 inch accuracy. The spacing between sprinklers varies from 55'-78'. The spacing as designed was 65'. The current spacing is inconsistent and makes the uniform application of water inconsistent as well. At the same time we noticed dry areas and wet areas. Many factors attribute to wet/dry areas including the multiple sprinklers per station, pressures and spacing. (Please refer to following page for GPS chart).

Pressures

During the course of the audit we tested pressure out of the sprinkler nozzles with a pitot tube. Across the entire course we never measured pressure above 65PSI. This indicates the pressure regulators designed to decrease pressure to a consistent level, are performing well where main line pressure is above 65PSI. The problem stems from the fact that most pressure was much lower than 65 on the front nine. During the daytime most pressure was measured between 55-60PSI. During the irrigation cycle, we tested pressures from 7:00-8:30PM. Pressures were recorded as follows;

Hole	Pitot tube pressure
1	55-65psi (depending on amount of sprinklers running simultaneously in area)
2	53psi – 2 green
3	40psi – 3 tee (during the day the pressure was 40-45)
4	No water running
5	43psi – 5 fairway
6	45psi - 6 tee
7	50psi – 7 tee (5 heads on simultaneously in same area)
8	45psi – 8 tee
9	No water running
10	60psi – 10 fairway (downstream of PRV)
13	58psi - 13 fairway (pressure at green on main line was 95 at same time)
14	60psi - 14 fairway (observed 10 sprinklers on at same time in fairway)
15	60psi - 15 approach
17	60psi - 17 fairway
18	60psi - 18 fairway

NOTES:

1. On #1 fairway during the day, 1 station with 2 sprinklers measured 60PSI out of nozzles
   When an additional station with 2 more sprinklers was turned on, pressure dropped to 50PSI.
   We conclude that adjusting hydraulics in the central in order to limit flows, will help sustain higher pressures during the nightly irrigation cycle.
2. Hole #12 - Satellite 411- stations 18 & 21, a part circle along lake edge turns on with both stations.
3. Many sprinklers across the entire course are low or tilted.
4. When #2 tee sprinklers activated, pressure on #1 green dropped to 43PSI from 55.
5. On #13 and #15, we observed pressure fluctuations during the catch can tests.

Based on the recorded pressures, it is evident that a serious pressure problem is downstream of the PRV on holes 1-9. If pressure is increased at the PRV to help correct this problem, it is possible that more main line pipe and fittings may fail.

Wiring and Multiple Sprinklers per Station

At The Golf Course there are anywhere from 1-5 sprinklers per station. It appears that all of the wiring was spliced in the field versus the satellites. This makes splitting up multiple sprinklers per station difficult since trenching or plowing in new wiring is the only option to achieve individual sprinkler control. Staff has performed some of this work in recent years on holes 4,10 &13. With the current wiring, if an area is too wet or dry, all of the sprinklers tied into that station must be adjusted as well. The detriment is overwatering or under watering due to the lack of specific area control. The ideal situation for controlling a golf irrigation system is to have each sprinkler wired separately and be one station. This is called individual sprinkler head control. An example of this problem can be found on #1 fairway. Satellite 215 – station #6 has three sprinklers. One of the sprinklers is keyed off at the sprinkler and two are on in order to control wet and dry areas within the same station.

Irrigation System Failures and expenses

Golf course staff have kept excellent records of all irrigation breaks and repairs for fiscal 2007-2008 & 2012-2013. The majority is "T" type and elbow fittings.(See picture below).The pipe and fitting range in size from 1.5"-8".

Broken "T" fitting on 4" main line

Pipe and Repair Materials	**Cost**	
6/10 – 5/11	$23,101	
6/11 – 5/12	7,881	
6/12 – 5/13	9,435	
6/13 – 9/13	4,192	(3 months only!)
Total for last 3.25 years	**$44,609**	**= $13,725 annually**

Repairs to system:

Date	# of repairs	Labor hours	Labor Cost
September, 2007 thru August 2008:	18	no record	
April 2012 thru August, 2013	37	293 hours	$ 3,619
Hand Watering -30 hours weekly		720 hours (estimate)	$11,520

There are additional costs other than parts and labor when there is a break in the system. There is irrigation downtime which affects the ability of staff to irrigate the affected area. With limited main line gate valves, several holes or more may not have irrigation available until the repair is made. This affects turf quality and creates inconsistent playing conditions for golfers. In addition, excavation of soils and future soil settling, can have a negative effect on the smoothness and playability of turf and soils. The repairing of breaks also interrupts play as seen on #17 fairway during the days of the audit.

Irrigation Water and Power Expense

The following data was provided and reflects these expenses for the given time periods.

Water	**Amount used**	**Cost**
6/11 – 5/12	100 miners	$20,008
6/12 – 5/13	100 miners	$20,809
6/13 – 5/14	100 miners	$21,641 (budgeted and estimated)

Electricity	**Cost**
6-10 – 5/11	$24,501
6/11 – 5/12	$14,520
6/12 – 5/13	$22,242
6/13 – 8/13	$12,140 (3 months only)

Note: The cost for water and electricity will never decrease. The varying expense for electricity year to year is most likely in direct correlation to the average rainfall. The PGE electricity invoices reveal a slight increase in cost per kilowatt hour from 2011-2013. The only ways to control and limit these costs include;

- Repairing leaking sprinklers and hydraulic pipes
- Decrease the amount of water by lowering run times or percentages (this has a direct effect on soil moisture, turf quality and playing conditions)
- Create out of play areas where irrigation sprinklers can be capped or turned off
- Remove turf and replace with bark or similar material
- Replace the entire irrigation system

These options have varying costs and all have an effect on turf conditions, course playability and property values. Creating out of play areas where areas are not irrigated typically end up as unsightly with weeds as the dominant inhabitant. Bark and ground cover used to cover these areas can be costly and all homeowners, golfers and interested committees must buy in to the potential changes to the course. A new irrigation system is the most costly of the options but provides the best overall result to the golf course. A new system distributes water more efficiently, thereby providing the ultimate control over water and energy use. Typically a new system comes with many decisions including;

- Should we add sprinklers where they are needed? (this adds to the cost)
- Should we irrigate the green surrounds separate from the greens? (this adds to the cost)
- Should we eliminate irrigation under the canopy of the oak trees? (This will add to the cost due to an increase in part-circle sprinklers needed).

Depending upon the answers to these types of questions, the amount of water used to irrigate with a new system may stay the same, decrease or could increase. The cost for all new irrigation equipment can do the same as well. The benefit is derived from the fact that water will be used more efficiently. Individual sprinkler adjustments allow the micro area management of all turf areas. A decrease in leaks and repair costs has a positive effect on the fiscal budget.

Estimated decrease in expenses with new irrigation system

	Annually
Water 6-10%	$ 1,248-2,165
Power 6-10%	$ 1,400-2,224
Labor & Parts 80%	$13,875
Hand Watering Labor 50%	$ 5,760
Total Potential Decrease	$24,024.00 (Annually)

The numbers above are conservative and based upon improving the efficiency of the irrigation system from the current D.U. average of 70% up to 76-80%. The system repair expenses will decrease the most. Hand watering and labor to repair breaks is most likely re-allocated to irrigation system and course maintenance. The water and power expense could decrease further but the savings depends on the new system and how many acres are irrigated.

Conclusion and Recommendations

Currently the two most reliable components of the irrigation system are the central computer and the pump station. The weakest component is the forty-year old hydraulic main and lateral lines. The life expectancy of irrigation components differ depending upon usage and maintenance. It is generally accepted that a golf irrigation system should be replaced every 15-25 years. The hydraulic system is on the higher end. If a new hydraulic pipe system is installed, it is common practice to replace station, communication and power wiring in the same trenches as the piping. Given that both satellites and sprinklers are 17 years old and becoming more costly to maintain, these also need replacement at Lake Wildwood.

Based on our evaluation and the age and costs to maintain the irrigation system, we recommend The Golf Course replace the entire irrigation system. The pump station does not need replacement but should be maintained and pumps tested for level of efficiency. A new irrigation system can be expected to range in cost from $1.5 – 2 million dollars. A preliminary design with cost estimates is needed to obtain a more accurate cost estimate. Should this option not be financially feasible at this time, we recommend the following short term procedures;

Short Term Irrigation Services and Procedures

1. Change hydraulics in central to limit amount of gallons flowing in all areas of golf course
2. Consider increasing pressure downstream of PRV (See note #1)

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3. Inventory sprinklers & nozzles. Following inventory change central database with correct data
4. Following inventory and recording all problematic sprinklers, begin replacement of leaking sprinklers and document location for warranty and replacement purposes.
5. From inventory identify low or tilted sprinklers and begin raising and leveling sprinklers
6. Schedule a pump efficiency test to determine the optimum output in gallons per minute
7. Budget for increasing annual costs to repair the irrigation system

Note #1 – Raising the downstream pressure on the PRV could cause more breaks and leaks in the hydraulic system on holes 1-9.

For the preliminary design and all short term changes, we have the experience to perform the work or know of industry specialists who can provide these services.

Once again, we thank The Golf Course for the opportunity. If you or any of the committees have any questions, please feel free to contact us at any time.

Sincerely,

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