Pump Efficiency Program

Providing completely integrated irrigation systems for efficient water management - from reservoir to rotor.

The Intelligent Use of Water.™

TABLE OF CONTENTS

INTRODUCTION: RAIN BIRD PUMP EFFICIENCY PROGRAM

SECTION ONE: PUMPS AND PUMP TESTING

SECTION TWO: EDUCATION

SECTION THREE: HELPFUL INFORMATION

RAIN BIRD PUMP STATIONS

RAIN BIRD® PUMP EFFICIENCY PROGRAM

OVERVIEW

Rain Bird® is the world's leading manufacturer of irrigation products. A pump station is the most important component of a irrigation system. Therefore, it stands to reason that Rain Bird is applying its expertise to the design and manufacture of pump stations, providing solutions that reliably and dependably deliver better turf, while lowering energy costs and ensuring pump station efficiency.

The Rain Bird Pump Efficiency Program derived from a program developed and managed by the Center for Irrigation Technology (CIT) on the campus of California Sate University, Fresno. The Program is funded by Pacific Gas & Electric (PG&E), using the Public Purpose Programs Fund under the auspices of the California Public Utilities Commission. With the resources of CIT, this booklet represents concepts and practices that can help reduce energy use, total energy costs, and improve overall resource efficiency.

The Rain Bird Pump Efficiency Program is intended to help improve energy efficiency and lower energy costs. This program achieves these goals by:

- Pump Efficiency Education
- Performing Pump Efficiency Tests
- Helping to install and maintain high-efficiency irrigation pumping plants
- Helping to manage these pumping plants correctly
- Offering assistance to locate incentive rebates for pump retrofits and repairs

This booklet provides information on how to obtain, maintain, and manage efficient pumping plants. It will help you understand the importance of pumping performance as it relates to managing energy use and lowering energy costs.

RESOURCES

Rain Bird Corporation
6991 E. Southpoint Rd. Bldg #1
Tucson, AZ 85756
Phone: (520) 741-6100
Fax: (520) 741-6522
Web address: www.rainbird.com/golf/products/pumpstations

The Center for Irrigation Technology (CIT)
California State University, Fresno
www.cati.csufresno.edu/cit

California Energy Efficiency
www.californiaenergyefficiency.com
www.agefficiencyplus.com

California Agricultural Pump Efficiency Program
www.pumpefficiency.org

Southern California Edison Energy Centers
www.sce.com/energycenters

New York State Energy Research and Development Authority
www.nyserda.org

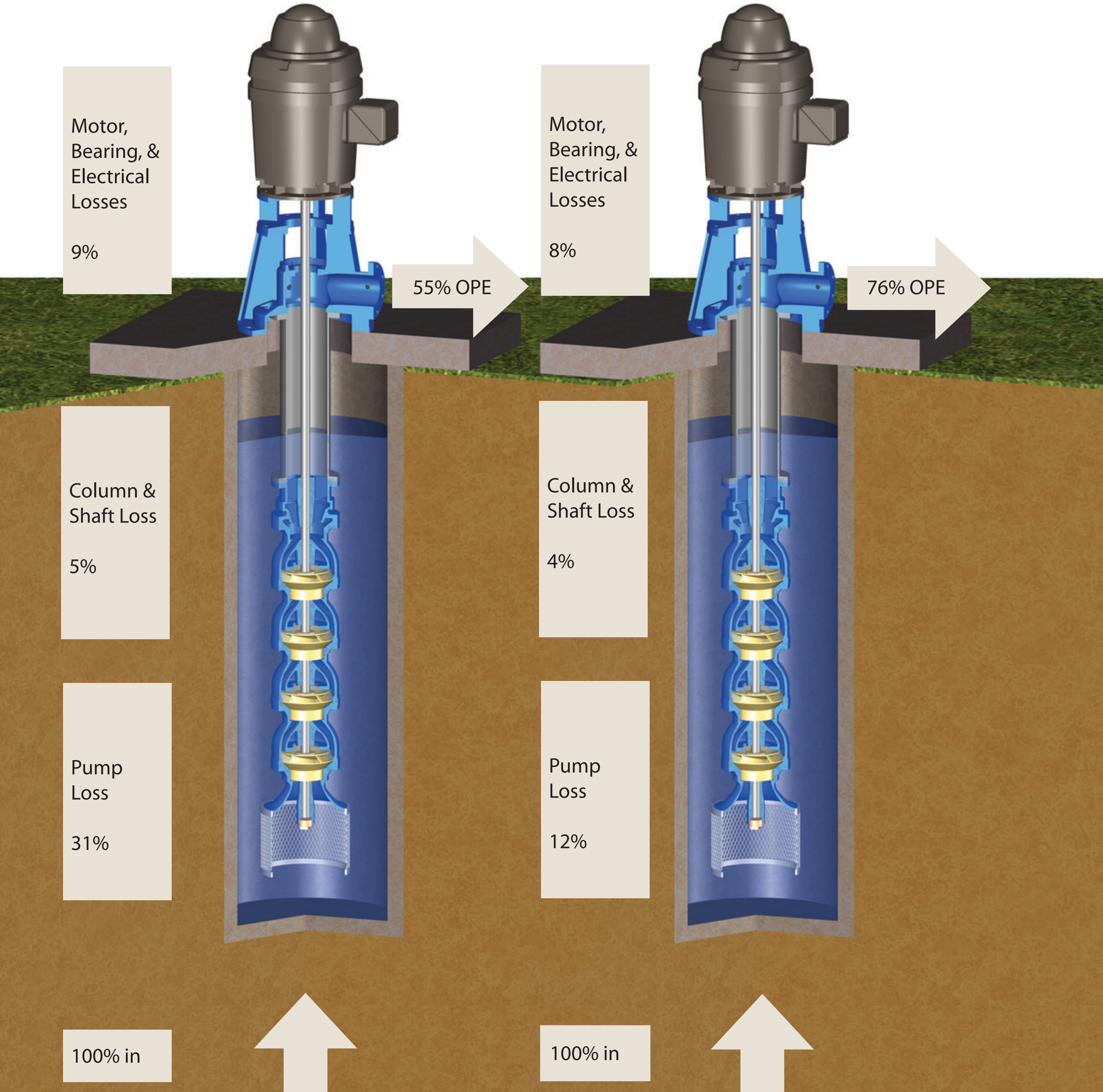
Florida Energy Office
www.dep.state.fl.us/energy

INEFFICIENT PLANT

TOTAL LOSSES = 45%

EFFICIENT PLANT

TOTAL LOSSES = 24%



Pump efficiency begins with selecting the right pump to move water in the volume needed. It is important to be knowledgeable of the required operating conditions and the variety of pump types and motors available to ensure that your system operates at the highest efficiency for those conditions.

PUMPS AND HOW THEY WORK

Pumps are classified as being either centrifugal or positive displacement. The pump type used in water industry pumping is the centrifugal pump. Centrifugal pumps have a variable flow/head relationship. Head is determined by the amount of lift of pressure resistance a pump must overcome in an application. A centrifugal pump will generate less flow with increasing head requirements. The type of centrifugal pump used or needed for the job should be based on the water and pumping requirements.

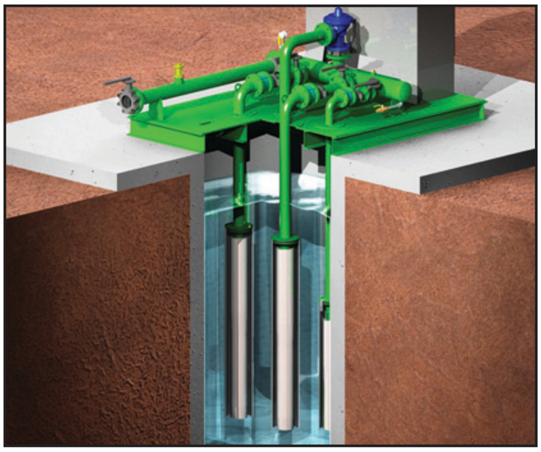
Centrifugal Pump Types

Turbine Pumps

The vertical turbine pump's motor is vertically mounted above the pump's discharge head and is coupled to the turbine pump via a vertical shaft. The vertical turbine pump operates inside the pump casing below the water level or to a water source under pressure. One or more sets of impellers and bowls on the shaft are assembled into a unit called the bowl assembly (the actual pumping element). The advantage to this pump type is the smaller and more compact design, which allows the pump to be installed in relatively small diameters in shallow or deep pumping applications. It is also more flexible for ease of maintenance and redesign.

Submersible Pumps

A submersible pump has a waterproof electric motor connected directly to a turbine pump; both the pump and the motor are in the water. A submersible pump is typically used when the space above ground is at a premium or when a straightline access to the water source is not possible. This pump is also much quieter than pumps that are above the ground.



Horizontal Pumps

The horizontal pump is usually a single-stage unit with one impeller mounted on a horizontal axis. The water enters the center of the rotating impeller and forces the water out radially to the outer diameter of the pump chamber, where it gains energy and is discharged. This draws in more water to achieve a continuous flow. These can be used as booster pumps or lift stations.

Note: optional stainless steel impellers offer excellent corrosion resistance; however, can result in additional pump efficiency losses. Bronze is typically the most efficient impeller material.

RAIN BIRD PUMP TEST

The goal of the Rain Bird Pump Efficiency Program is to assist their customers in making the most efficient use of electricity to save money and energy. The pump test is an estimate of the overall efficiency of your pump and the total cost of running it under the conditions of the test. Rain Bird's trained Pump Testers will conduct a complete and accurate efficiency test on each pump individually.

Reasons for Testing

If an existing pump has undergone a mechanical breakdown and is operating below average, most likely energy is being wasted. Likewise, if the pump is simply not able to produce the required flow and pressure needed, then a repair retrofit or replacement may be needed.

New pumps should also be tested to establish a baseline performance for future comparison and verify that the equipment is operating as designed.

What a Pump Test Measures

To determine the Overall Pumping Plant Efficiency (OPE), a pump test measures the following aspects:

- Rate of flow
- Total Head (Pumping Lift & Discharge Pressure)
- Power input to the pumping plant

Preparing for the Test

To do a complete cost analysis, the Pump Tester will incorporate the following information:

- Hours of operation or annual Acre Feet pumped
- Average energy cost/KWh
- Normal operating conditions
- Required rate flow
- Discharge pressure
- Description of the system (where is the water going?)

Meeting Test-Ready Requirements

On the day of the test, the Pump Tester will need:

- Suitable Location for Flow Determination
- Ability to interrupt operations for equipment setup (in some cases, testing may be completed without shutdown)
- Ability to run equipment for extended period (15 minutes - 2 hours)

Accurate flow measurement is key to obtaining accurate pump efficiency. In order to obtain an accurate measurement, the water flow in the pipe must be free from turbulence.

If a flow meter is unavailable, there are alternative methods available to determine flow.

The Test Results

After the test is completed, you will receive a detailed report of your results including the data gathered and recommendations regarding financial and energy savings. Your pump test representative and the results from your pump test will help you identify which pumps to examine, evaluate and possibly replace, repair or retrofit.

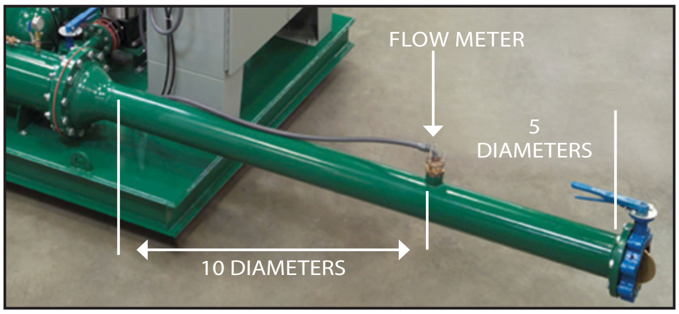
The test results will also show what your annual savings could be if you address the problems and make changes to improve the OPE of any or all pumping plants. Your pump test representative will explain yearly changes, cost of operations and suggest potential solutions.

The Importance of Regular Pump Testing

A pump should be tested every one to three years, depending on annual usage and severity of operating conditions. For example, you may want to test a well pump that pumps a lot of sand-filled water yearly, but test a booster pump supplied by clean water once every three years.

Having routine tests conducted allows you to evaluate the system's condition over time. Regular pump testing not only helps maintain efficiency and keep energy costs in check, it can also help prevent serious problems from arising, like a system breakdown. Pinpointing a potential problem allows you to investigate the situation and perform an objective analysis to identify when it is financially beneficial to make changes to the system, including possible pump repairs or retrofitting.

Minimum Flume Requirements



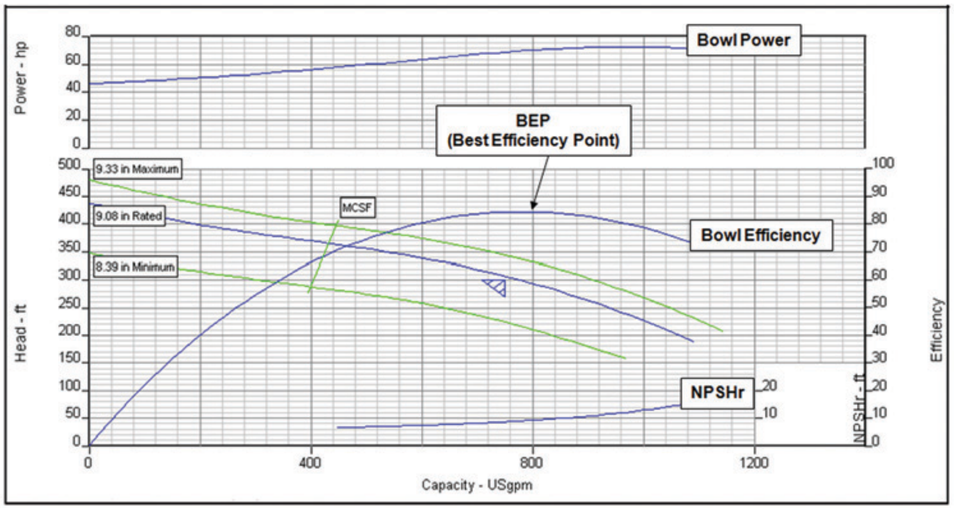
PUMP-PERFORMANCE CURVE

Pumps have the ability to perform in a range of operating conditions. Pump manufacturers publish pump-performance curves for each pump type. Utilizing a pump-performance curve along with the pump test results can provide further insight to a pump's performance.

The pump-performance curve is a charted or graphed illustration that portrays a pump's range of operating conditions. It shows the relationship between pump flow (in gallons per minute), pumping pressure (in feet), water horsepower and Net Positive Suction Head (NPSH).

Why They are Useful

Pump-performance curves can help you see what effect increasing or decreasing the pumping pressure will have on a pump productions (measured in gallons per minute or GPM) and horsepower requirements. You can take the results from your Rain Bird Pump Efficiency Test and actually overlay them onto the manufacturer's pump-performance curve to determine actual pump operating conditions.



Bowl Power – The power input required to generate a given flow and pressure.
Bowl Efficiency – The ratio of hydraulic power output from the bowl to the power input to the bowl
e.g. A bowl with required a 75HP motor to generate a 50HP hydraulic output would have a Bowl Efficiency of 50/75 = 67%
BEP (Best Efficiency Point) – Point of highest bowl efficiency. You want your operating point to be as close to BEP as possible.
NPSHr – Net Positive Suction Head Required – Pressure required on the intake side of the pump to ensure proper operation.

PUMP TEST COST ANALYSIS

If your OPE is low, Rain Bird will provide you with a Pump Cost Analysis, which compares your plant's present operating performance to what it could be if it were operating in optimal conditions.

The cost analysis is based on assumptions that water requirements will remain the same and all operating conditions remain the same (Total Head and Water Demand). Based on these assumptions, the cost analysis letter will estimate the following:

- Estimated potential improvement in OPE
- Estimated energy savings kWh/year and $/year

Below are the calculations that determine the potential savings that can be obtained by improving OPE:

Total kWh - The total kilowatt hours used annually based on hours of operation
kW Input - Input kW as measured by the test representative
kWh per Acre Foot - The kilowatt-hours required to pump an acre foot of water into the system
Acre Feet per Year - The estimated acre feet per year pumped into the system
Average Cost per kWh - The acreage cost per kilowatt-hour based on previous 12-month billing
Average Cost per Acre Foot - The average cost to pump an acre foot of water through the system
Overall Plant Efficiency (OPE) % - The overall pumping plant efficiency (which may be zero in the case where the pumping water level in a well cannot be measured for some reason)
Total Annual Cost - The estimated annual cost of energy may not include demand charges or other surcharges to run the pump. This will be zero if the annual hours of operation or annual acre feet pumped are not known

TEST RESULTS: The letters on pages 6 - 11 are examples of what you would receive from your Rain Bird Pump Tester after your Pump Performance Test is completed.

GOLF PUMP PLANT EFFICIENCY SUMMARY LETTER

RAIN BIRD®

Golf Course
Attn:
Address
City, St. Zip

Test Date: 7/10/2008
Analysis Date: 7/20/2008

Pump Tested: Golf Course Main Irrigation Station
Equipment: Rain Bird VFD
Pump #1 50 HP Vertical Motor Turbine Pump – 74.4% Plant Efficient
Pump #2 50 HP Vertical Motor Turbine Pump – 70.2% Plant Efficient
Pump #3 15 HP Vertical Motor Turbine Pump – 73.2 % Plant Efficient

In accordance with your request, a test was made on your pump station on July 10th, 2008. The pumps were tested gathering an Overall Plant Efficiency for each individual pump as seen above and attached with the following documentation. An estimated cost analysis was also completed based on the information gathered and provided by you. New pumping plant efficiencies were used to express potential savings. In addition to the individual pump reports and data, please note below key points:

1. This Station is performing efficiently as expected.
2. The low set point of 107 assists in allowing for efficient operation.
3. The check valve on pump #3 requires immediate attention.
4. The potential savings is negligent. It is recommended to continue testing on a regular basis. The next test should be performed in 2 to 3 years.
5. A cost analysis will not be provided for efficient pumps; however, cost results (seen on the Pumping Hydraulic Test Results page) may be valuable.
6. Pacific Gas & Electric offers rebates and incentives for retrofit/repair of inefficient pumps. Go online at www.pumpefficiency.org for more information.

If you have any questions about the attached test results, please contact your pump test representative.

Sincerely,

Rain Bird Pump Sales Manager

The above letter provides a detailed summary of an entire pumping plant.

RAIN BIRD®

Golf Course
Attn:
Address
City, St. Zip

Test Date: 7/11/2008
Analysis Date: 7/20/2008

Pump Tested:
S/N:

In accordance with your request, a test was made on your pump station on July 10th, 2008. If you have any questions about the below test results, please contact your pump test representative. Also see the included Pumping Cost Analysis.

Hydraulic Results

Inlet Pressure or Lift:	**0**
Discharge Pressure (PSI):	**107**
Standing Water Level (Feet):	**5**
Draw Down (Feet):	**1**
Pumping Water Level (Feet):	**6**
Total Head (Feet):	**261**
Measured Flow Rate (GPM):	**799**
Customer Flow Rate (GPM):	**799**
Gallons pumped in 24 Hours:	**1,150,560**
Acre/Feet pumped in 24 Hours:	**3.53**
Cubic Feet per Second (CFS):	**1.78**
kW Input to Motor:	**52.8**
HP Input to Motor:	**70.8**
Water HP	**52.7**
Motor Load (%):	**104%**
Measured Speed of Pump, RPM:	**N/A**

Cost Results

Cost per Hour ($/Hour):	**$6.60**
Cost to Pump a Million Gallons:	**$137.67**
Cost per Acre/Foot:	**$44.28**
Base Cost per Kwh:	**$0.125**
Overall Plant Efficiency (%):	***74.4%***

The above letter provides detailed pump test results along with cost results of a single 60 HP pump. This example reflects an OPE of 74.4%, which is considered EXCELLENT performance for this pump. See table on page 17.

Golf Course
Name
Address
City, St. Zip

Test Date: 7/11/2008
Analysis Date: 7/20/2008

Pump Tested: Golf Course Station
Equipment: Cloudburst Panel VFD
Pump #1 50 HP Vertical Motor Centrifugal Pump – 65.5% Efficient
Pump #2 50 HP Vertical Motor Centrifugal Pump – 56.5% Efficient
Pump #3 15 HP Vertical Motor Centrifugal Pump – 30 % Efficient

In accordance with your request, a test was made on your pump station on July 11th, 2008. The pumps were tested gathering an Overall Plant Efficiency for each individual pump as seen above and attached with the following documentation. An estimated cost analysis was also completed based on the information gathered and provided by you. New pumping plant efficiencies were used to express potential savings. In addition to the individual pump reports and data, please note below key points:

1. The on site flow meter is not accurate. This flow meter would need to be relocated with a minimum length upstream of 8x the diameter of the pipe installed in and minimum length downstream of 2x the diameter of the pipe. In order to obtain accurate measurement, the water flow in the pipe must be free from turbulence. An offsite meter was used during the efficiency test to obtain more accurate results.
2. The boosting application of your existing pump station takes good advantage of the incoming pressure.
3. Using an estimated combined annual water use of 392 acre/feet or current annual expense of $10,330, a more efficient new station could be expected to save approximately $2,084 annually. Over a ten year minimum life expectancy that could accumulate to $20,840 in efficiency savings.
4. Pacific Gas & Electric offers rebates and incentives for retrofit/repair of inefficient pumps. Go online at www.pumpefficiency.org for more information.

If you have any questions about the attached test results, please contact your pump test representative.

Sincerely,

Rain Bird Pump Sales Manager

The above letter provides a detailed summary of an entire pumping plant. Note the highlighted pumps would be considered inefficient (see table on page 17).

RAIN BIRD

Golf Course
Attn:
Address
City, St. Zip

Test Date: 7/11/2008
Analysis Date: 7/20/2008

Pump Tested:
S/N:

In accordance with your request, a test was made on your pump station on July 11th, 2008. If you have any questions about the below test results, please contact your pump test representative. Also see the included Pumping Cost Analysis.

Hydraulic Results

Inlet Pressure or Lift:	**N/A**
Discharge Pressure (PSI):	**58**
Standing Water Level (Feet):	**N/A**
Draw Down (Feet):	**N/A**
Pumping Water Level (Feet):	**N/A**
Total Head (Feet):	**138**
Measured Flow Rate (GPM):	**755**
Customer Flow Rate (GPM):	**699**
Gallons pumped in 24 Hours:	**1,087,000**
Acre/Feet pumped in 24 Hours:	**3.3**
Cubic Feet per Second (CFS):	**1.68**
kW Input to Motor:	**34**
HP Input to Motor:	**46**
Water HP	**26.3**
Motor Load (%):	**86**
Measured Speed of Pump, RPM:	**N/A**

Cost Results

Cost per Hour ($/Hour):	**$ 4.30**
Cost to Pump a Million Gallons:	**$ 94.86**
Cost per Acre/Foot:	**$ 30.92**
Base Cost per Kwh:	**$0.125**
Overall Plant Efficiency (%):	***56.6%***

The above letter provides detailed pump test results along with cost results of a single 50 HP pump. This example reflects an OPE of 56.6%, which is considered FAIR performance for this pump. See table on page 17.

RAIN BIRD®

Golf Course
Attn:
Address
City, St. Zip

Test Date: 7/11/2008
Analysis Date: 7/20/2008

Pump Tested:
S/N: .

The following analysis is presented as an aid to your cost accounting. This is an estimate based on the conditions present during the Rain Bird certified pump test performed on July 11th, 2008, any billing history provided and your current electrical rate.

Assuming that water requirements will be the same as for the past year, and all operating conditions (annual hours of operation, and water pump level) will remain the same as they were at the time of the pump test, it is estimated that:

1. Overall Pump Efficiency can be improved from 57% to 72%
2. This can save you up to 7,353 kWh and $919 annually.

Pumping Cost Analysis

Pump Location/Description
Spyglass Hill Pump #2 Booster

	Plant Efficiency		
	Existing	**Improved**	**Savings**
Estimated Total kWh/Year	**34379**	**27026**	**7353**
Estimated Acre Feet per Year	**139**	**139**	
kWh per Acre Foot	**247.3**	**194.4**	**52.9**
Average Cost per kWh	**$0.125**	**$0.125**	
Average Cost per Acre Foot	**$30.92**	**$24.30**	**$6.61**
Overall Plant Efficiency (%)	***56.6%***	***72%***	
Total Annual Cost	**$4,297.38**	**$3,378.21**	***$919.16***

I believe you will find this information to prove valuable and that your concerns over maintaining optimum pumping efficiency will be continued. If you have any further questions regarding this report, please contact your Pump Test Representative

Sincerely,

Rain Bird Pump Sales Manager

This is a continuation of the previous letter explaining the cost analysis of the pump.

RAIN BIRD

Pump Efficiency Hydraulic and Cost Data

Pump Location/Description		**Pump Make:**	Flow Serve
		Pump Serial Number:	N/A
Customer Contact Name			
Customer Address		**Type:**	Vertical Turbine
Customer Phone:		**Motor Make:**	U.S. Motor
Customer Fax:		**Motor Serial Number:**	N/A
Customer Cell:		**Motor Voltage:**	460
Customer Email:		**Motor Amps:**	73
		Name Plate RPM	1770
Motor Horse Power:	60	**Motor Efficiency**	88.5%
Utility Company:	PG & E	**Meter Number:**	0042R9
			85609429
Test Date:	7/10/2008	**Tester:**	

Hydraulic Results		Hydraulic Test Result Formulas
Inlet Pressure or Lift:	**0**	Use Pressure Gauge is applicable
Discharge Pressure (PSI):	**107**	2.31 ft = 1 P.S.I.
Standing Water Level (Feet):	**5**	Water Level while *NOT* Pumping
Draw Down (Feet):	**1**	Difference in Standing Water and Pumping Water Level
Pumping Water Level (Feet):	**6**	Water Level while Pumping
Total Head (Feet):	**261**	Discharge Head plus Pumping Water Level
Measured Flow Rate (GPM):	**799**	Using any additional method of finding flow rate
Customer Flow Rate (GPM):	**799**	Customer Meter flow rate
Gallons pumped in 24 Hours:	**1,150,560**	GPM x 60 x 24
Acre/Feet pumped in 24 Hours:	**3.53**	(GPM x 60 x 24)/(325,851)
Cubic Feet per Second (CFS):	**1.78**	GPM/448.8
kW Input to Motor:	**52.8**	On-site Utility Meter, Wattmeter, or Volt & Amp Meters
HP Input to Motor:	**70.8**	kW input x 1.341
Water HP	**52.7**	(GPM x Total Head) / 3960
Motor Load (%):	**104%**	HP Input x Motor Eff / Name Plate HP
Measured Speed of Pump, RPM:	**N/A**	Use RPM Gauge if available

Cost Results		
Cost per Hour ($/Hour):	**$6.60**	KW Input x Kwh Cost
Cost to Pump a Million Gallons:	**$137.67**	((1,000,000/GPM)/60 min) x Cost Per Hour
Cost per Acre/Foot:	**$44.88**	(.326) x Cost to Pump Million Gallons
Base Cost per Kwh:	**$0.125**	See Utility Bill
Overall Plant Efficiency (%):	***74.4%***	(Water HP/Input HP) x 100

The above example is a detailed data sheet used to provide the test results for the example on page 7-8.

PUMP TEST KEY TERMS

Discharge Pressure, PSI - The pressure obtained at center line of pump discharge pipe using a calibrated gauge (psig). Discharge pressure is converted to feet and expressed as "Discharge Head".

Standing Water Level, Feet - The well's water level obtained when pumping plant is at rest, also referred to as Static Water Level.

Drawdown, Feet - The measured distance, in feet, that a well's water level changes from standing/static level to operating pumping level during observed test conditions.

Suction Head - Head (in units of feet) measured above center line of pump suction intake. Most often obtained with calibrated bourdon tube pressure gauge (suction pressure) and converted to feet by conversion factor 2.31 ft. water/psi.

Suction Lift - The distance in feet between pump discharge head and water level. Typically measured utilizing a measuring tape or via calibrated vacuum pressure gauge by conversion factor 1.13 ft./psi.

Discharge Head Feet - Head (in units of feet) measured above center line of pump discharge pipe. Most often obtained with calibrated bourdon tube pressure gauge (discharge psig); pounds per square inch are converted to discharge head by conversion factor 2.31 ft. water/psi.

Pumping Water Level, Feet - The well's operating water level below center line of discharge pipe as observed during test conditions.

Total Head, Feet - The sum of the water head above and below the center line of the pump discharge pipe. For well applications, the Total Head is the sum of the Discharge Head and the Pumping Water Level. For booster applications, the Total Head is either determined by subtracting the Suction Head from the Discharge Head or adding the Suction Lift to the Discharge Head. Total Head is used in determination of water horsepower. It is also useful as a comparison and evaluation of current operations to the pump's design point and/or to past pump operations/conditions.

Capacity, GPM - Flow expressed in gallons per minute. This flow is obtained through the use of equipment (in most instances a Pivot tube). Capacity is used to calculate water horsepower.

Power Factor - The percentage of apparent electrical power (volts x amps) that is actually available as usable power. The ratio of True Power to Apparent Power.

True Power - Measured in watts and is the power drawn by the electrical resistance of a system doing useful work.

Apparent Power - Measured in volt-amperes (VA).

GPM per Foot Drawdown - The ratio of capacity (GPM) to drawdown feet. GPM/Ft Drawdown is useful in determining the well's performance, trending well performance year-to-year, and may provide information to be used in designing proper pump to meet application. Factors that may affect the well's performance include (but are not limited to); aquifer conditions, well casing diameter, well screen/strainer, the gravel pack and/or the initial design of the well and pump. This reading is a measure of well performance, not pump performance.

Acre Feet Pumped in 24 hours - Amount of water, in Acre Feet, pumped per day at the measured capacity, GPM. One Acre Foot of water is equivalent to 325,851 gallons of water.

kW Input to Motor - Input kW determination obtained through timing of electronic meter or by calibrated handheld electronic kW meter. The kW input is converted to horsepower to calculate input horsepower.

HP Input to Motor - The power input to driver, expressed in horsepower, obtained by converting input kW to horsepower (1.341 kW per 1 horsepower).

Motor Head (%) - The calculated motor load based on the ratio of brake horsepower (horsepower at motor output shaft obtained by factoring motor efficiency) to nameplate horsepower. Brake horsepower is equal to horsepower at the output shaft of motor. The motor load should be generally between the ranges of 70 - 115%.

Measured Speed of Pump, RPM - Measured rotational speed, revolutions per minute, of pump shaft as determined by tachometer.

kWh per Acre Foot - The amount of Kilowatt Hours required to pump one acre foot of water. Value obtained using pump test results. Useful in determining pumping costs. Cost to pump an acre foot of water can be calculated by multiplying this value by the current cost/kWh.

Overall Plant Efficiency (OPE %) - The ratio of the water horsepower (the overall output of plant) to input horsepower (the power input). The overall output can also be defined as the amount of horsepower required to deliver the measured capacity (water gallons per minute) and the measured total head (in feet). Overall plant efficiency is used in determining overall condition of pumping plant at observed test conditions. Two main components that contribute to OPE are motor efficiency and the pump efficiency.

Customer Meter (GPM) - Flow as indicated by the customer's meter.

FORMULAS

Discharge Head: Discharge pressure (psi) x 2.31 feet/psi

Suction Head (Booster Applications): Suction pressure (psi) x 2.31 feet/psi

Suction Lift (Booster Applications): Lift (in feet) or vacuum pressure gauge reading (Hg) x 1.13 feet/psi

Total Head: (Wells) Discharge head + pumping level (ft.)
(Boosters with positive suction) Discharge head - suction head
(Boosters with Lift) Discharge head + suction lift

$$\text{GPM per Ft. Drawdown} = \frac{\text{GPM}}{\text{Drawdown, Ft.}}$$

$$\text{Acre Ft. Pumped in 24 hours} = \frac{\text{GPM x 60 min./hr. x 24 hrs.}}{\text{325,851 Gal./Acre Ft.}} = \frac{\text{GPM}}{226.3}$$

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

Meter Multiplier = The "MULT" value on the meter face
Disk Constant = The "k_h" value on the meter

Input KW (volt-amp) = V x A x P.F. x 1.732/1000
P.F. = Power Factor on motor name plate

HP Input to Motor: kW input x 1.341

$$\text{Water Horsepower (Output HP of Pump)} = \frac{\text{GPM x Total Head}}{3{,}960}$$

$$\text{Motor Load (\%)} = \frac{\text{HP input x Motor Efficiency as a \%}}{\text{Name Plate HP of Motor}}$$

$$\text{kWh per Acre Ft.} = \frac{\text{Input kW x 325,851 Gal. / Acre Ft.}}{\text{GPM x 60 min./hr.}} = \frac{\text{Input kW x 5,431}}{\text{GPM}}$$

OPE (%) = (Water Horsepower / HP Input) x 100

$$\text{HPIN} = \frac{\text{Flow x TDH}}{\text{39.60 x OPE}}$$

Estimated Shaft Losses: 1 HP per 100 feet of shaft

Estimated Thrust Bearing Losses: Motor Efficiency x Input HP x 1%

Brake HP to Impeller: (Input HP x Motor Efficiency) - Thrust Bearing and Shaft Loss

$$\text{Impeller Efficiency (\%)} = \frac{\text{Water HP}}{\text{Brake HP x 100}}$$

CONVERSIONS

Pressure (Head)

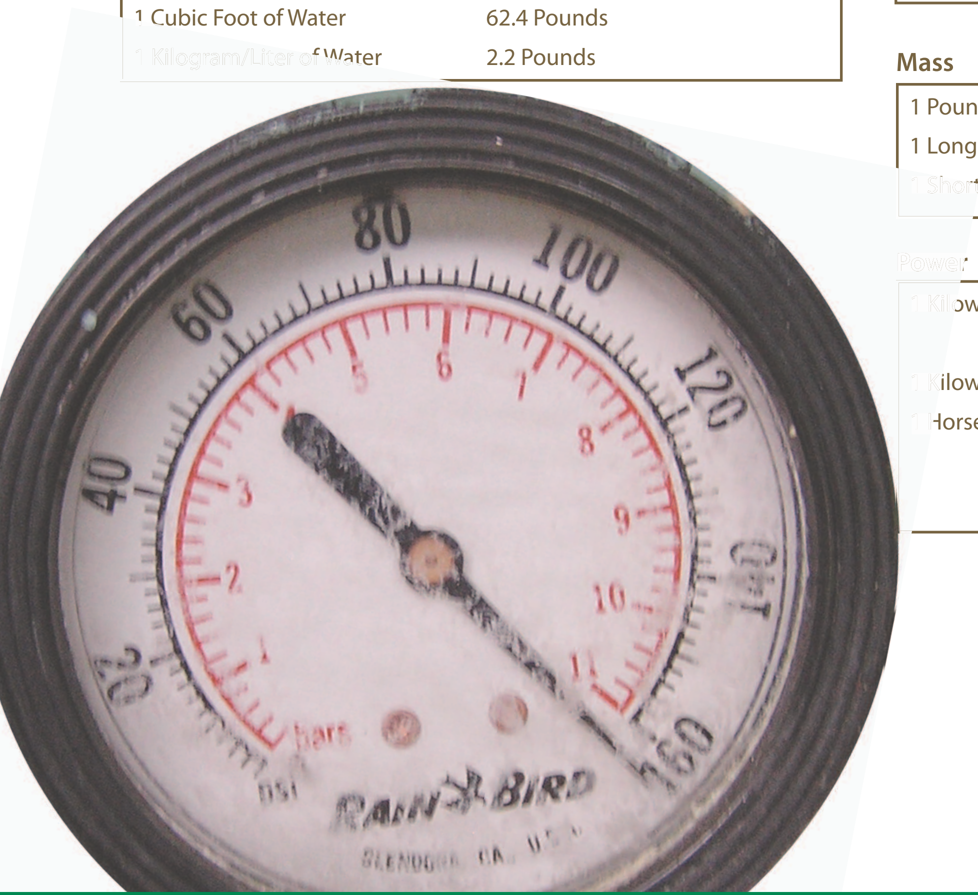
1 Atmosphere	14.70 psi
	34 Feet of Water
	10.4 Meters of Water
1 Pound per Quare Inch (psi)	2.31 Feet of Water Head
	6.9 Kilopascals
	2.04 Inches of Mercury
	0.703 Kilograms per Square Centimeter
1 Foot of Water Head	0.433 psi
	0.883 Inch Mercury
1 Kilogram per Square Centimeter	14.2 psi
1 Inch of Murcury	1.13 Feet of Water

Flow Rate (Capacity)

1 Cublic Foot per Second	448.8 Gallons per Minute (GPM)
1 Liter per Second	15.85 GPM
1 Acre Inch per Hour	452.6 GPM
1 Cubic Meter per Minute	264.2 GPM
1,000,000 Gallons per Day	694.4 GPM
1,000 Gallons per 24 Hours	1.44 GPM

Weight of Water Volumes

1 U.S Gallon of Water	8.345 Pounds
1 Cubic Foot of Water	62.4 Pounds
1 Kilogram/Liter of Water	2.2 Pounds



Volume

1 U.S. Gallon	3.785 Liters
	231 Cubic Inches
	0.1337 Cubic Feet
	0.00379 Cubic Meters
1 Cubic Foot	7.4805 Gallons
	0.0283 Cubic Meter
1 Liter	0.2642 Gallons
1 Barrel	42 Gallons
1 Acre Foot	325,851 Gallons
	43,560 Cubic Feet
1 Acre Inch	27,154 Gallons
	3,630 Cubic Feet
1 Cubic Meter	264.2 Gallons
	35.3 Cubic Feet
1 Cubic Centimeter	0.06102 Cubic Inch
1 Cubic Inch	16.39 Cubic Centimeters

Length

1 Inch	2.54 Centimeters
1 Mile	5,280 Feet
	1,609 Meters
	1,609 Kilometers
1 Foot	0.3048 Meter

Mass

1 Pound	0.4536 Kilograms
1 Long Ton	2,240 Pounds
1 Short Ton	2,000 Pounds

Power

1 Kilowatt	1.341 HP
	0.102 Boiler HP
1 Kilowatt Hour	3,413 BTU per Hour
1 Horsepower	0.746 Kilowater
	33,000 Foot Lbs per Min
	2,545 BTU per Hour

THE IMPORTANCE OF PUMP PERFORMANCE

A variety of factors can alter a pump's performance and cause energy and money to be wasted. Pumps don't have to be broken in order to be ineffective; many working pumps can be working inefficiently. That is why it is critical to evaluate your pumping plant's operating efficiency.

A pumping plant's operating efficiency is determined by factors such as:

- Type and size of pump
- Condition of pump
- Pump speed
- Total head or pump pressure
- Conversion of mechanical energy (pump) to water energy (water flow), motor efficiency, power efficiency
- Transmission of water flow through pipes, fittings, valves, etc.
- Condition of the well

PUMP EFFICIENCY, ENERGY DEMANDS AND COSTS

Energy costs alone are a significant percentage of overall operating expenses. When one or more pumps are not operating efficiently, it takes more energy than necessary for the pump to perform as needed. It is also possible that even if the pump or pumps are operating properly, the pumping-system management may be insufficient. Assessing your pumping plant's performance and performing pumps tests regularly can help you avoid interruptions to your operations, help you manage energy costs, and help you improve overall plant-operating efficiency.

Example of an Inefficient vs. Efficient Pump: The example assumes that OPEs do not lessen or change over a 5-year period. Total Head does not change and water demand remains the same. The 5-year comparison example also assumes $40,000 cost for improvement and shows an efficiency payback over a 5-year period.

	INEFFICIENT PUMP	EFFICIENT PUMP	SAVINGS
Overall Efficiency	55%	76%	
kWh/Acre Ft	649	498	151
Acre Ft./Year	523	523	
Annual kWh	339,427	260,454	78,973
Cost per Year @ $.11/kWh	$40,731.24	$31,254.48	$9,476.76

5-YEAR COMPARISON: INEFFICIENT VS. EFFICIENT OVERALL PLANT EFFICIENCY

	INEFFICIENT PLANT	EFFICIENT PLANT			PAYBACK
	Annual Cost @ 55% OPE	Annual Cost @ 76% OPE	Annual Operational Savings	Replacement Costs	Annual Savings
Year 1	$40,731.24	$31,254.48	$9,476.76	$40,000	($30,523)
Year 2	$40,731.24	$31,254.48	$9,476.76		($21,046)
Year 3	$40,731.24	$31,254.48	$9,476.76		($11,570)
Year 4	$40,731.24	$31,254.48	$9,476.76		($2,093)
Year 5	$40,731.24	$31,254.48	$9,476.76		$7,384
5 YEAR TOTALS	$203,656.20	$156,272.40	$47,383.80		

The calculation indicates an ROI in approximately 4 years and an overall savings of $47,383.80 after 5 years.

MOTORS, PUMPING PRESSURE, AND PIPES

Many physical and design aspects of you pumping system may affect its performance including the type of motors used, size of pipes, and the actual pumping pressure to name a few.

Energy-Efficient Motors

Motors are an essential part of your pumping system, converting electrical energy into mechanical work to move water. Today, motors are designed to be more efficient and are able to convert a higher percentage of their electrical input to useful mechanical work. Motor manufacturers are using higher-quality, more expensive materials like iron and copper. They are not 100% efficient, due to frictional and electrical losses. Some electrical motors have less heat loss than others.

Purchasing a new, high-efficient motor may be more economical overall versus repairing a damaged motor. The following is an example of savings for a premium efficient motor over a standard motor at 75% Motor Load and 2000 hours of operation.

Motor HP	Standard Efficiency Motor	Annual kWh 2000 Hours Operation	Premium Efficiency Motor	Annual kWh 2000 Hours Operation	Energy Savings kWh/Year	Energy Savings $/Year
25	90	31,080	93.9	29,800	1,280	$143
50	91.2	61,357	94.8	59,044	2,313	$254
100	92.7	120,679	95.4	117,271	3,408	$375
150	93.1	180,331	95.8	175,136	5,195	$571

Variable Frequency (Speed) Drive

You can reduce pumping energy and costs by using a variable frequency drive (VFD) to control pressure and flow. A VFD-controlled pump can maintain constant pressure when the flow is changing and can also be used to keep a constant flow when the pressure is changing. Both cases result in optimum productivity with reduced energy usage.

A VFD improves a pump's performance by changing its rotational speed to better match the pumping load. The most efficient VFDs use solid-state inverters. A sensor in the pumping system signals the VFD circuits to vary the voltage and frequency outputs, which changes the pump speed.

Excessive Pumping Pressure

Your pumping system should maintain the minimum pressure required to operate efficiently. Excessive pumping pressures can be the result of:

- A defective booster pump control and valves
- Pumping against a higher head than is needed to move water (false head)
- Supplying water at a pressure exceeding state regulations

Piping System Friction Losses

Large diameter pipes have less flow resistance per unit of flow than smaller pipes. Pipelines are usually sized enough to keep fluid velocities and Total Head losses at acceptable levels. The design involves a balance between expenditures for pipe, treatment requirements, system requirements, and overall energy consumption based on design.

OPE: OVERALL PUMPING PLANT EFFICIENCY

Knowing your Overall Pumping Plant Efficiency (OPE) will help you manage your energy costs. The OPE is the relationship between the power consumed in kilowatts and the amount of water delivered in gallons per minute at a given pumping head, in feet. Basically, the OPE is the percentage of how much water horsepower is needed by the pumping plant from the input horsepower to the motor.

The pumping plant's power source takes electrical energy and converts it into the rotating mechanical energy of the pump impeller. The pump then takes the mechanical energy and converts it to fluid energy, moving water at a certain pressure and flow. Therefore, the more efficient the pumping plant, the lower your energy bill to move the same amount of water.

OPE Rating

The OPE , presented as a percentage, is determined by factors such as:

- Bowl efficiency - the pump's efficiency at converting mechanical energy to moving water
- Driver efficiency - the efficiency of the electric motor
- Transmission shaft efficiency - a measure of loses that occurs in transmission
- Frictional losses - losses due to mechanical friction within plant, pipe, pump and equipment

OPE can only be measured by a pump test. Knowing your OPE can help you make informed and important business decisions in order to lower your current pumping requirements, reduce total energy used, and track trends for budgeting and forecasting.

WIRE-TO-WATER EFFICIENCY

"Wire-to-water" efficiency of a pumping plant is the ratios of work done by a pumping plant to the energy put into the pump. The pumping plant is defined as the pump and motor equipment and controls; including all associated fittings from the water source through the pump to the discharge into the distribution system.

An OPE in the low to fair range suggests that a pump may need a retrofit, repair, or adjustment, or that the pump is not matched to the current required operating conditions. For example, the water table may have dropped significantly over time, increasing the total lift above the original specifications.

The following table of OPE performance ranges for surface mounted motor pump plants. Remember that the efficiency for a submersible motor is generally 3-5% lower than a standard motor because of electrical energy line losses going down the well.

OPE Ranges: Wire to Water

MOTOR HP	Low	Fair	Good	Excellent
3-5	41.9 or less	42-49.9	50-54.9	55 or above
7-10	44.9 or less	45-52.6	53-57.9	58 or above
15-30	47.9 or less	48-55.9	56-60.9	61 or above
40-60	52.9 or less	53-59.9	60-64.9	65 or above
75-up	55.9 or less	56-62.9	63-68.9	69 or above

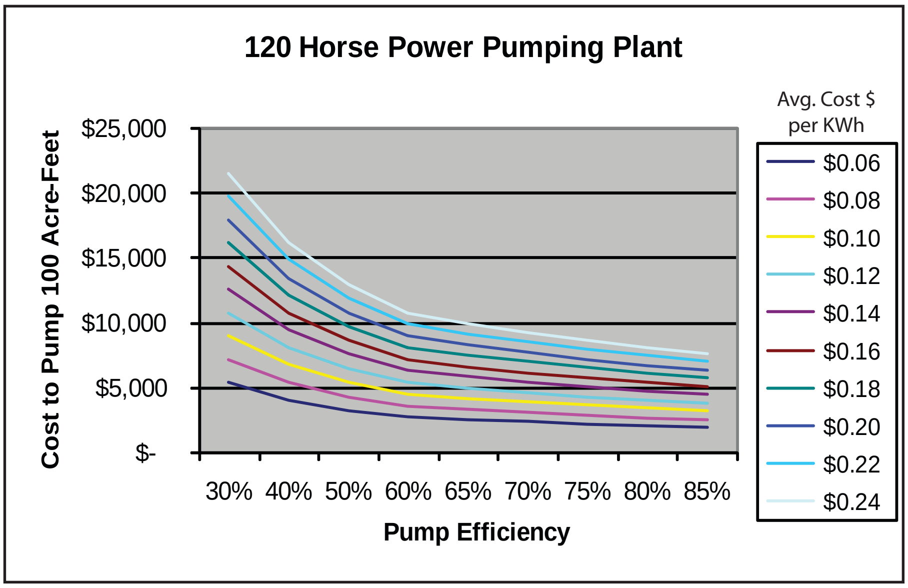
Note: The above values developed by Center for Irrigation Technology (CIT).

ONGOING SYSTEM MANAGEMENT

Pumping plant efficiency should be monitored regularly through accurate record keeping. Rain Bird can help you investigate the problems with pumps that test at a low OPE. There are programs that can help address problem areas, reduce your energy costs, and offer incentives such as hardware discounts and rebates.

Example of Total Savings by Improving OPE: The graph is an example of a 120 HP Pumping Plant 100 Acre Ft at a setpont of 115 psi.

Input HP =120
Input KW = 89.52
Total Head = 265
100% Efficiency Flow = 1793 GPM
WHP = (GPM x Total Head)/3960



Using $0.12 per kWh:

- Cost to pump 100 Acre Ft @ 40% OPE = $8,063
- Cost to pump 100 Acre Ft @ 75% OPE = $4,300

TOTAL SAVINGS IF OPE IS IMPROVED = $3,763 per 100 Acre Feet

FREQUENTLY ASKED QUESTIONS

1. How long does it take to conduct a pump efficiency test?
An average test takes one to three hours. This includes about 15 minutes preparation time and 30 minutes - one hours pumping plant run time.

2. How much does the pump efficiency test cost?
The cost of a pump test varies. In some regions, pump testing may be subsidized, typically by a public utility company. Contact your Rain Bird Distributor, Rain Bird Authorized Service Provider (ASP), or an independent pump test company for normal hourly rate.

3. Who can fix my pump?
Take your pump efficiency test results to a qualified pump contractor or Rain Bird Authorized Service Provider (ASP) to make efficiency improvements for your pumping plant. When a complete replacement is necessary, Rain Bird Pump Distributors can help you specify and order a new energy efficient station.

4. How do I request a pump test?
Contact your Rain Bird Distributor, Rain Bird Authorized Service Provider (ASP), or an independent pump test company.

5. How often should I get a pump test?
Generally, a well pump with average to high usage should be tested every one to two years. Booster pumps should be tested every two to three years.

6. My system is brand new, so why is it not 100% efficient?
The pump test measures the Overall Plant Efficiency, which incorporates many factors such as the type and size of the motor, the type and size of the pump and other factors associated with frictional and electrical losses. Motor efficiencies generally range between 85-96% and pump efficiencies generally range from 70-80+%.

7. What kind of pumps will Rain Bird Test?
Rain Bird will typically test all types of pumps; however, some pumps cannot be tested if there is no method to receive accurate flow data.

8. What do I need to do to allow for a pump test?
In general, the following is required to conduct a complete test:

- Ability to stop and start all pumps
- Ability to operate pump at peak capacity for 15 minutes - 1 hour
- Ability to measure or calculate flow based on demand
- Ability to measure electric input
- Ability to measure water depth in well
- Ability to measure Total Head or pressure

9. What size HP pump can we test?
5 HP and up.

Acidification: Injecting an acid chemical (usually hydrochloric acid or sulfuric acid) into a well to dissolve encrusted material on the casing slots.

Acre Foot: The volume of water required to cover one acre of surface land with water, one foot deep (325, 851 gallons).

Adjustable Speed Drive: Drive speed at shaft adjusted either mechanically or electrically to control speed of pump. Refer to Variable Frequency Drive.

Apparent Power - Measured in volt-amperes (VA).

Application Rate (AR): Equivalent depth of water applied to a given area per hour by the system, usually measured in inches per hour.

Aquifer: A saturated water-bearing, geographical formation or group of formations having sufficient permeability to yield water to wells.

Axial Flow Pump: Pump design used for low-head, high-flow conditions; also called a propeller pump.

Belt Drive: A device that transmits power from a motor to a pump by means of belts (either flat or V-belts) and pulleys.

Booster Pump: A pump used to lift or introduce water from a low surface level (reservoir, canal, lake, river or pond) to a higher level or greater pressure of water system. Can be a horizontal or a turbine pump.

Bowl Pump: The pump stage of a turbine pump or called the "volute" of a centrifugal pump. It contains the rotating impeller and directs water flow into and out of the impeller.

Brake Horsepower (BHP): The output horsepower of a motor to a pump; may also be used to refer to the required input horsepower to the pump itself.

Capacity (Pump): The flow rate of a pump, generally referring to the normal (or required design) flow rate of the pumping plant.

Casing: Pipe used as lining for a well.

Cascading Water: Water entering a well at a point above the pumping water level, which can trap air in the water and cause a significant loss of pumping efficiency. Cascading water could be an indication of an insufficient well or a signal of aquifer changes.

Cavitation: The rapid formation and collapse of air bubbles in water as it moves through a pump., resulting from too high a vacuum in the pump itself due to insufficient "net positive suction head". Causes pitting of the propeller and pump housing and can degrade the pump performance.

CCF: Hundred cubic feet.

CFS: Cubic feet per second, as a rate of flow where large quantities of water are considered.

Centrifugal Pump: A pump in which water enters the center of a rotating impeller and is flung out radically, gaining energy in the process.

Check Valve: A valve installed in a pipeline that automatically closes and stops water from flowing backwards when a pump is shut off.

Column Loss: The value of head loss caused by low friction in the well column pipe.

Column Pipe: The pipe that connects the bowl assembly of a turbine pump to the discharge head of the pump and conducts the water from the bowl assembly to the discharge head.

Concentric Reducer: A symmetrically-shaped pipe fitting used to constrict and divert flow from a larger or smaller pipe.

Corrosion: Deterioration and destruction of metal by chemical and/or galvanic reactions. Chemical corrosion dissolves metal, which is carried away by the water. Chemical corrosion can also allow sand to enter the well. Galvanic corrosion is caused by electrolytic cells forming between dissimilar metals or surfaces.

Deep-Well Turbine Pump: A turbine pump installed inside a well casing below the pumping water level in the well.

Discharge Pressure: Pressure at the discharge flange of a pump.

Discharge Head: A measurement of pressure, in feet of head, at the discharge flange of a pump. It can also be a physical part of a turbine pump base, which supports the column pipe and bowl assembly.

Distribution Uniformity (DU): A measurement of how evenly water soaks into the field during irrigation. It is usually a percentage and the higher the number the better.

Drawdown: The difference in elevation between static and pumping water levels in a well, usually following a specific operating time.

Driver: A prime mover (motor) that supplies power to a machine (pump), generally a windmill, electric motor, or internal combustion engine.

Driver Efficiency: The ratio of the driver output to the power input, typically expressed as a percentage.

Dynamic Head: The sum of the pressure and pumping head developed by a pump.

Eccentric Reducer: A non-symetrically shaped pipe fitting used to constrict and divert flow to a smaller pump without leaving an air space at the top of the large pipe.

Electric Motor: A device that converts electrical energy to mechanical work.

Electric Sounding Probe: Device used to measure water level in a well by completing an electrical circuit when a probe is lowered into the well water.

Encrustation: The accumulation of material in the perforations of the well casing, in well screen openings, and in the voids of gravel pack and water-bearing soil. Encrustation decreased open areas in the well casing, impedes water flow into the well, and decreases well efficiency.

End Seal: A seal on the bottom end of the impeller in a turbine pump bowl assembly.

Entrained Air: A mixture of small air bubbled within water. It can be caused from vortexing or cascading water into the well, which displaces water from the impeller and reduces pump capacity and efficiency.

Feet of Head: A measure of pressure in a water system (1 foot of head = .433 psi).

Field Capacity: The amount of water the soil will hold.

Float Switch: An electrical switch in the control circuit of a motor control that is actuated by a float in a water tank or reservoir.

Flow Meter: Used to measure fluid flow rates in a pipe or open channel, measuring instant flow rates or total fluid volumes over a period of time.

Friction Head: The head, in feet, required to overcome the fluid friction in a pipe or water system.

Friction Losses: Energy losses associated with moving water against rough surfaces. In water pumping applications, it is the water pressure lost as a result of contact between moving water and a pipeline or open channel.

Gal/Min. (GPM): Gallons per minute as a rate of flow.
Gate Valve: Used to control flow by lifting or closing a gate. All gate valves have a rising or non-rising stem. Rising stems provide a visual indication of valve position. Non-rising stems are used where vertical space is limited or underground.

Gear Drive: A mechanical device using gears to connect a driver to a pump, usually to provide different pump speeds.

Head (Water Head): Alternative term for pressure. One pound per square inch (1 psi) = 2.31 feet of water head.

Head Capacity Curve: A pump performance curve of a particular impeller type showing the relation of dynamic head and flow rate.

Horsepower (HP): A rate of doing work - how far a mass can be moved in a period of time. One HP = 33,000 foot pounds per minute (1HP can raise 33,000 lbs one foot in one minute).

Impeller: The rotating component of the pump and is contained within the pump bowl. It transfers energy developed by the pump driver to the water as water flows through the pump bowl.

Impeller Trim: The diameter of the impeller.

Input Horsepower: The HP input to a pumping plant. Value can be calculated from electrical, diesel, or propane power using standard conversion factors.

Irrigation Efficiency (IE): A measure of how much water that is pumped and applied to a field is beneficially used, usually expressed as a percentage.

Kilowatt: A unit of electrical power, 1000 watts.

Kilowatt-hour (kWh): The amount of energy expanded by a one kilowatt device over the course of one hour.

Line shaft: Used to connect a motor to the impeller of a turbine pump.

Line Shaft Loss: The power, expressed in HP kW, required due to the rotation friction of the line shaft. This value is added to the bowl assembly input to predict the pump input.

Manometer: A portable device using velocity head (the energy of the moving water) to measure water flow rates in pipelines. Commonly used in pump efficiency tests.

Megohmmeter: Measures electric motor insulation resistance.

Motor: A rotating machine that converts electrical power into mechanical power.

Motor Load: The output HP of an electric motor divided by the rated HP of the motor. Expressed as a percentage, generally between 80 and 115%.

Multi-Condition Pump Test: A pump efficiency test where pump performance is measured at various Total Head and capacity conditions. Can be used to determine pump's best efficiency point and as a comparison to pump performance curve.

Multi-Stage Pump: A pump having more than one impeller/bowl assembly, commonly in turbine pumps.

Net Positive Suction Head (NPSH): A design requirement dependent on the individual pump. The NPSH must be stated at the pump inlet to prevent cavitation.

Oil Tubing: In a turbine pump, the oil tubing encloses the line shaft of the pump giving it rigid, vibration-free support. IT extends from the top of the bowl assembly in the well to the pump discharge head at the ground level.

Operating Condition: The combination of flow and pressure (total dynamic head) developed by the pump. A pump can operate at a number of operating conditions as defined by its pump performance curve.

Operating Cost: The sum of expenses necessary to keep a pumping plant in operation. Includes cost of energy, lubrication, maintenance, repair and labor.

Overall Pumping Plant Efficiency (OPE): A measure of how much water HP is produced by the pumping plant from the input HP. It is the combination of three efficiencies: bowl efficiency, driver efficiency, and transmission efficiency.

Packing: Flexible material used around a pump shaft (between the rotating shaft and pump case) to prevent leakage of the fluid being pumped.

Parallel Pumps: Two or more pumps (often different size for flexibility) discharging into a common pipeline to increase the flow rate at a given pressure in the pipeline.

Power Factor - The percentage of apparent electrical power (volts x amps) that is actually available as usable power. The ratio of True Power to Apparent Power.

Pressure Relief Valve (PRV): A mechanical device that senses system pressure and compares it with a pre-set spring pressure. When hydraulic pressure exceeds spring pressure, the PRV actuates to reduce system pressure.

Pressure Switch: An electrical switch in the control circuit of a pump motor that is actuated by the pressure of the water in a water system.

Programmable Logic Controller (PLC): Serves as the brain for the pump station. Required for pump stations utilizing additional features.

psi: pounds per Inch - a measure of pressure in a water system. A vertical column of water 2.31 feet high will exert a pressure of one pound per square inch (1 psi).

Pump: A mechanical device that converts mechanical energy into hydraulic energy.

Pump Case: The body of a pump that encloses the impeller and directs the flow of water from the suction to the discharge of the pump.

Pump Curve: A graph that illustrated the performance of a pump from zero to maximum capacity. It will also indicate the head and HP of the pump.

Pump Discharge: The point at which water is discharged from a pump or a pump base; also known as Discharge Head.

Pump Efficiency Test: A series of measurements and calculations providing information concerning performance of the pump (and of the well, if applicable). The test will indicate the overall pumping plant efficiency (OPE), pump flow rate, required pump input HP, and the discharge pressure.

Pump Performance Curve: A set of measurements showing the relationship between Total Head, HP requirements, and net positive suction head requirements at any given flow rate for a pump.

Pumping Head: The difference in elevation between the pump water level and the pump discharge.

Pumping Lift: The distance from the center line of the discharge pipe at the pump head to the water level in the pumping well.

Pumping Water Level: The elevation of the water level in a well during pumping.

Radial Bearing: One of the two bearings in a vertical electric motor.

Revolutions Per Minute (RPM): The rotating shaft of a pump or driver (motor).

Sand Separator: A device installed on the pump intake pipe in deep-well turbine pumps to remove sand from the water before it can enter the pump.

Semi-Open (Semi-Closed, Mixed Flow) Impeller: An impeller where water enters the ye of the impeller and exits at less than a 90 degree angle.

Series Pumps: Two or more pumps installed so that one pump discharges into the intake or another pump, increasing pressure at a given flow rate. The Total Head developed by the second pump is asses to the Total Head of the first pump. Example: a well pump discharging into a booster pump.

Single-Stage (Pump): A pump having one impeller/bowl assembly.

Shaft (Pump): The round bar to which the impeller of the pump is fastened, transmitting the rotational energy of the motor to the impeller.

Sounding a Well: The process of determining where the water level is in a well. This could be the static water level or the pumping water level.

Sounding Tube: A small pipe extending from above the foundation or grout seal into the well casing to allow access for sounding the well.

Static or Standing Water Level: The elevation of the water level in a well at rest (pump off).

Straightening Vanes: Metal strips attached to the inside of a pipe that straighten out the flow of turbulent water to provide more symmetrical flow when measuring flow rates.

Suction Bell: A bell-shaped fixture placed on the suction intake of pumps to decrease energy losses.

Suction Lift (Suction Head): Distance form the water surface to the pump intake when the pump is located above the water surface.

Submersible Pump: A deep-well turbine pump with a waterproof electric motor that is connected directly to a turbine pump, both installed in the well below the pumping water level.
Surging: Fluctuating flow of water from a pump that is attempting to pump more water than is flowing into the pump.

Tailwater Reuse/Return System: A system used to recover and reuse irrigation runoff.

Test Suction: The section of pipe or open channel where flow measurements are taken.

Thrust Bearing: The bearing in the turbine pump discharging head of the vertical hollow shaft motor that supports the vertical downward thrust of the turbine pump.

Time-of-Use-Rates (TOU): Electric power rate schedules where different costs are associated with different times of use. For example, lower rates are offered during "off-peak" periods and higher rates are charged for "on-peak" periods (when power use is the highest for utility).

Totalizer: A type of flow meter that provides a measure of total water volume flowing past a point over time.

Total Dynamic Head (TDH): The total dynamic discharge head minus the total suction head (OR plus the total dynamic suction lift). It is a pressure that is responsible for lifting the water to the soil surface (if in a well), overcoming pressure losses caused by friction and elevation differences, and providing the required operating pressure in the system.

True Power - Measured in watts and is the power drawn by the electrical resistance of a system doing useful work.

Turbine Pump: A centrifugal pump with a vertical shaft and smaller bowls; it can be installed in a well of any depth. Often, multiple pump assemblies are stacked on top of each other and the water is directed by the pump bowl upwards to the next impeller/bowl assembly to match system demand.

Ultrasonic Flow Meter - Either Doppler or Transite-time meter measuring flow through a pipe using ultra-sonic transducers.

Variable Frequency (Speed) Drive (VFD): Used to change the frequency of AC electric energy supplied to an electric motor. Varying the frequency of the AC current will vary the speed of the motor, which is helpful in situations that require many different operating conditions on a regular basis.

Vertical Hollow Shaft (VHS) Motor: A vertical induction motor with a hollow motor rotor.

Vortex: A whirlpool leading into the pump inlet., caused by insufficient submergence of the pump intake or poor design of the pump intake works. They are undesirable as they can entrain air.
Voltage: The electromotive force that causes electrons to move through a circuit.

Water Horsepower (WHP): The output horsepower of a water pump. It is the combination of flow rate and pressure.

Water Level: The distance in feet between the ground level and the water surface in a well.

Wear Ring: A part of the pump that provides a water seal between the impeller and the pump case, sealing the high pressure side of the impeller from the low pressure (suction) side.

Well Casing: Pipe used as the lining for a well. A layer of rack (gravel pack) is usually placed between the well casing and the aquifer to help prevent soil particles from entering the well.

Well-Specific Capacity: The rate of flow being pumped from the well divided by the total drawdown as measured during test condition. Expressed in gallons per minute (GPM) per foot of drawdown.

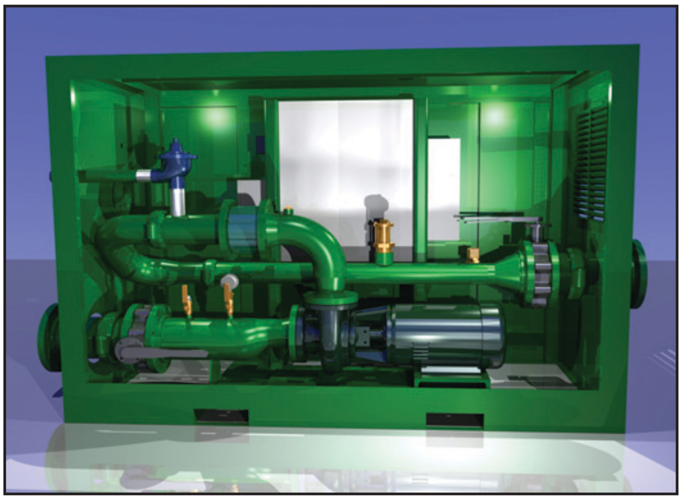
RAIN BIRD® PUMP STATIONS

Rain Bird has built its own facility in Tucson, Arizona, dedicated to the manufacture of pump stations. This state-of-the-art facility was designed by experts with years of pump station experience. The plant features on-site, operational testing, including a wet well, to further assure each Rain Bird Pump Station meets or exceeds established industry standards and satisfies specific golf course irrigation requirements. Trust that when you choose Rain Bird, over seven decades of irrigation expertise is at work to make sure your pump station will perform reliably and efficiently.

Rain Bird offers a variety of pump station options to meet your specific needs. These options include pre-fabricated skids with vertical turbine lift pumps, horizontal centrifugal flooded suction or suction lift pumps, self contained booster pumps, split-case water feature pumps, submersible or floating skid pumps and more. Featuring Variable Frequency Drive technology or Constant Speed stations, every station is engineered and custom built for the specific users requirements.

Additional Customization Includes:

- Pressure Maintenance and/or Jockey Pumps for smaller daily watering needs
- Pumps from 3 H.P. to 100 H.P
- Up to 6 Main Pumps
- Custom skids and retrofit options
- Integrated filtration systems
- Additional Power Zones



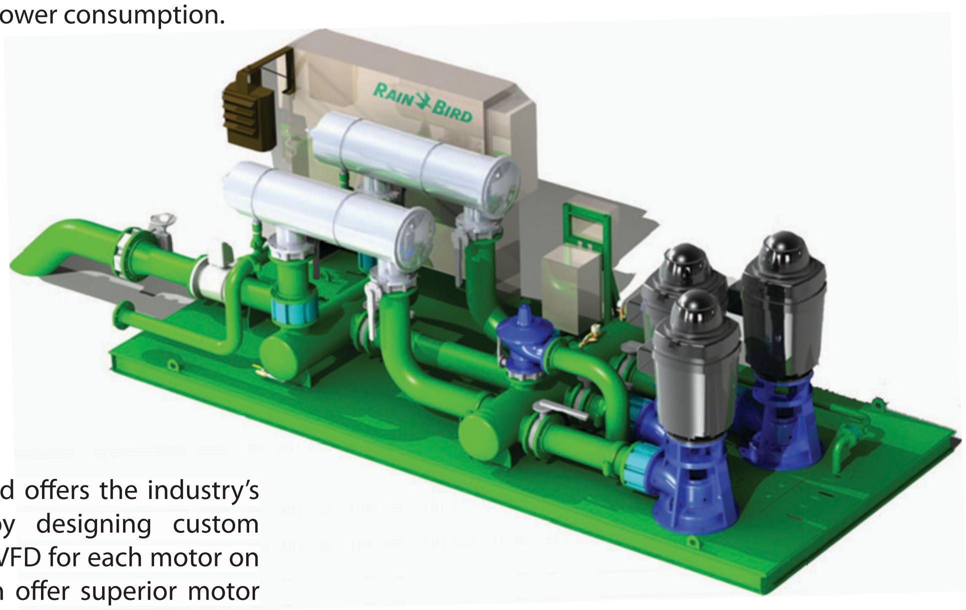
Quality and Durability

Electrical Design - Rain Bird Pump Station use a sophisticated suppression system to reduce the risk of electronic component damage that could lead to inconvenient and costly downtime. This includes full heavy duty circuit breaker integration that provides protection for the motor and is easier and less expensive to service.

Engineered Pump Station Skid Design – Using 3D modeling, the channel steel skid frame is engineered for strength and rigidity. This engineering reduces vibration and eliminates the requirement for oversized pump mounting plates. The top deck is the industry's strongest and longest lasting by providing 3/8" plate throughout with heavy duty ½" pump mounting plates continuously welded on top of the engineered frame.

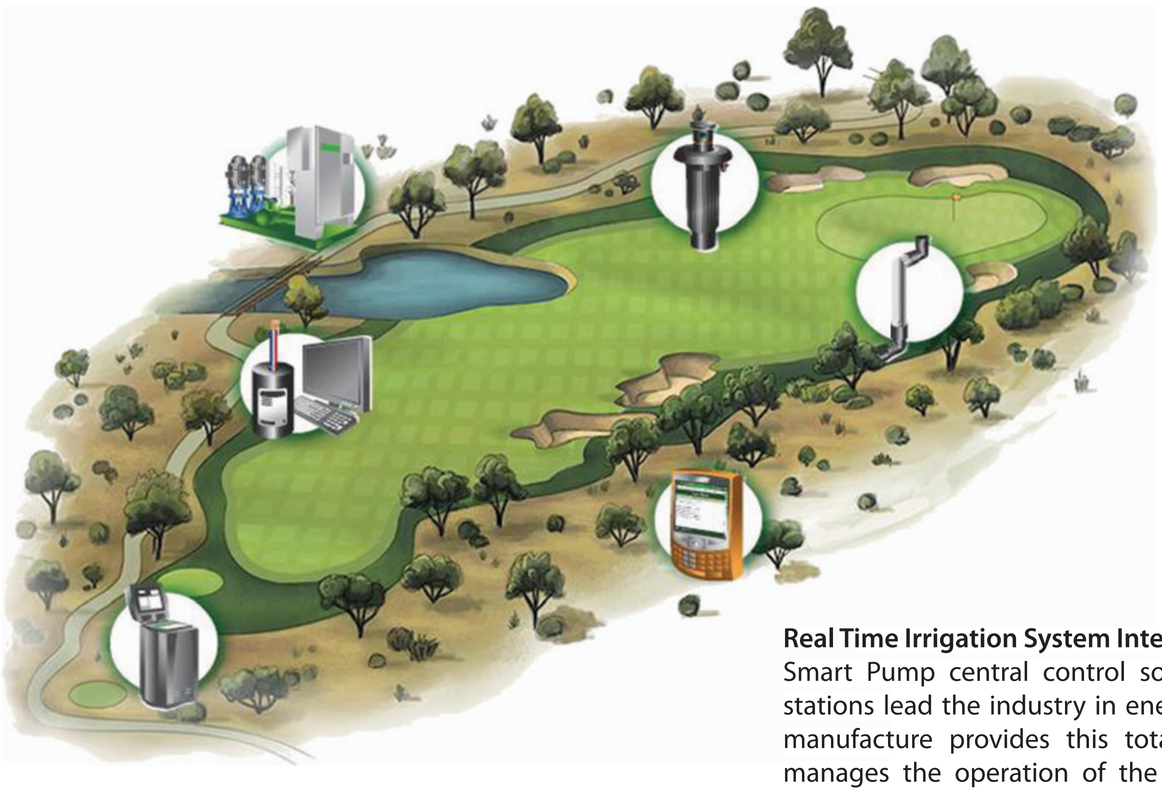
Durable Polyester Powder-coating – Rain Bird's in-house sandblasting system assures all surfaces of the pump station are prepared properly to allow for the best coating adhesion. The polyester powder-coat Rain Bird applies is far more durable than liquid coatings, and will not deteriorate over time like other coatings that often develop a chalky appearance. In fact Rain Bird's powder coating process scored a 10 out of 10 on an ASTM corrosion test provided by Sherwin Williams. Other industry pump stations scored 4 out of 10 on the very same test. In addition, the powder-coating process is environmentally friendly

Cascading VFD – Rain Bird offers cascading VFD as a standard feature. This allows every motor to be started on the VFD taking full advantage of the reduced stress of soft starting along with more efficient power consumption.



Solid VFD Panel Option – Rain Bird offers the industry's most comprehensive package by designing custom stations upon request to include a VFD for each motor on a multi pump station. This option offer superior motor protection along with no mechanical switching.

Advanced Controls – Using a simple to operate touch screen interface, Rain Bird offers the most advanced control package in the industry.



Real Time Irrigation System Integration – With Rain Bird's Smart Pump central control software, Rain Bird pump stations lead the industry in energy efficiency. No other manufacture provides this total integration and truly manages the operation of the pump through out the irrigation cycle.

MAIN IRRIGATION PUMP STATIONS

Flows Up to 10,000 gpm (2,300 m3/h)

- Enhanced Serviceability – Modern electrical design utilizing industrial breaker motor protection instead of time-wasting fuses. Industrial circuit breakers are quickly reset and designed for an extended service life
- Reduced Downtime – Modern electrical design that uses industrial circuit breaker motor protection instead of time wasting fuses. Industrial circuit breakers are good for thousands of trips
- Easy Operator Training – English and Spanish color touch-screen that is easy to learn

Features

- Reduced Cost: Powder coat paint earned the highest rating on ASTM corrosion tests. Less corrosion equals longer pipe, skid, and manifold life, reducing cost
- No-Hassle Buying: Everything you need for your irrigation system construction or renovation from the only manufacturer dedicated to irrigation
- Real-time communication between the pump station and Rain Bird's Central Control

Application

Reliable Variable Frequency Drive Pump Stations designed to serve as the main irrigation pump station for large commercial sites and projects. Rain Bird's Pump Systems are designed for both new construction projects and can be custom built for tough-to-fit renovation projects.
Available in the following configurations:

– Vertical and submersible turbine pump stations for wet well applications
– Horizontal end suction for flooded suction, suction lift, and pressure boosting applications
– Multistage pumps for flooded suction and pressure boosting applications where differential pressures greater than 130 psi (9 bar) are required

Options

- Air conditioned electrical panel cooling system
- Custom controls
- Custom piping and manifolds
- Enclosures: aluminum, painted steel (government specified colors) or stainless steel
- Fabricated discharge heads
- Fertigation systems
- Filtration: backwashing screen filters and suction scan filters (hydraulic or electric)
- Heater, skid mounted 5KW
- Intake box screen with 3 stainless steel screens
- Lake level control: float switch and ultrasonic
- Magnetic flow meter
- Modem, radio or hard-wired
- Power zones: 5, 7.5, or 10KVA
- Totally enclosed, fan cooled (tefc) motors
- Wye strainer with auto back-flush
- Z discharge pipe
- Hdpe piping and manifolding

Electrical Power Specifications

- 60 Hz, 3-Phase Power: 230V (up to 60hp per pump), 460V, 575V
- 50 Hz, 3-Phase Power: 190V (up to 60hp per pump), 380V, 415V
- 60 Hz, 1-Phase Power: 230V (up to 30hp per pump)

EV TWIN VERTICAL PUMP STATIONS

Providing up to 1500 GPM (340 m3/h) at 20 psi (8.3 bar) for 60Hz/460V-575V applications and up to 273 m3/h at 8,3 bar for 50Hz/380V-415V applications.

The EV Twin Vertical Turbine Pump Stations are intended for standard wet-well applications with a 48" (1.2m) to 60" (1.5m) diameter and a depth of either 12' (3.66m) or 15' (4.57m).

- Easy Operator Training - Intuitive Monochrome Touch Screen is easy to navigate, unlike text based displays
- Easy Installation and Start-up - All stations are wet-tested prior to shipment
- No hassle buying and single point responsibility Purchase all irrigation system components from one supplier

Features

- Variable Frequency Drive (VFD) for maximum energy efficiency
- Air to Liquid Control Panel Heat Exchanger for maximum VFD life
- NEMA 4 Electrical Panel for maximum protection of electrical components
- RU Vertical Turbine Pump Motors
- Electrical Power Surge Protection
- Power-loss auto-restart ensures seamless operation on loss/regain of electrical power
- Modern electrical design employs industrial grade circuit breaker motor protection instead of outdated and expensive to replace fuses.
- Complete skid and piping garnet blasted and powder coated for maximum corrosion resistance
- Pressure relief valve with butterfly isolation valve protects the station from over pressurization while ensuring serviceability.
- Stainless steel pressure transducer for maximum durability
- Mechanical actuated air relief system to ensure smooth system operation
- Individual pump silent check valves and isolation valves

Features (continued)

- Integral wet-well service hatch
- Lake level floats prevent inadvertent dry-running of vertical turbine pumps
- 3HP (2.2kW) Stainless Steel Pressure Maintenance Pump and Motor

Options

- Non Reverse Ratchets for Vertical Turbine Pump Motors
- Magnetic Flow Meter
- Wye Strainer

Application

Golf Courses, Commercial, and Municipal sites utilizing a wet-well and requiring the redundancy of a twin vertical turbine system to deliver up to 1,500 GPM at 120 psi for 60Hz applications, and up to 273 m3/h at 8.3 bar for 50Hz applications.

Electrical Power Specifications

- 60Hz, 3 phase Power: 460V or 575V
- 50Hz, 3 phase Power: 380V or 415V

D/DP/DPX-SERIES (Integrated Plug-in Pump Stations)

Flows Up to 300 gpm (68 m3/h) and Greater, Discharge Pressures Up to 150 psi (10.3 Bar)

- Reliability – Integrated Plug-n-Pump Stations (up to 300gpm) provide single source responsibility for the entire pumping system insuring trouble-free installation and operation
- No-hassle Buying – Purchase all irrigation system components from Rain Bird facility in Tucson, Arizona
- Easy Start-up – All stations are wet tested prior to shipment

Features

- Vertical Multistage Pump for flooded suction or pressure boosting applications
- Horizontal End-Suction Pump for flooded suction, pressure boosting, or suction-lift applications
- Variable frequency drive for maximum energy efficiency
- Monochrome-backlit touch screen operator interface makes for easy operator training
- Power-loss auto-restart ensures seamless operation on loss and regain of electrical power

Options

- Flow meter (mechanical or magnetic)
- Pressure relief valve
- Vandal resistant enclosure in PGS8-C0651 fence green or FS 20450 night tan

Electrical Power Specifications

- 60 Hz, 3-phase power: 230V, 460V, 575V
- 50 Hz, 3-phase power: 190V, 380V, 415V
- 60 Hz, 1-phase power: 230V (up to 10 hp per pump)

D-Series Features

Drive-only pump system that cost effectively delivers no-frills high performance.

D-Series Applications

Residential and commercial flooded-suction, pressure boosting, and suction lift irrigation applications requiring a reliable no frills pump station delivering the pressure and flow rate required by the irrigation system.

DP-Series Features

Programmable logic controller (PLC) allows controls beyond pressure and flow such as lake level controls, actuated automation filtration, and the ability to alter pressure set points based on time (variable pressure settings).

DP-Series Application

Residential and commercial flooded-suction, pressure boosting, and suction lift irrigation applications up to 300 gpm, with pressures up to 150 psi requiring programmable logic controls.

DPX-Series Features

- Seamless system integration with Rain Bird's SiteControl software (requires optional full color touch screen)
- Liquid-cooled NEMA 3R electrical panel ensures reliability and longevity in hot climates
- Programmable logic controller (PLC) allows controls beyond pressure and flow such as lake level controls, actuate automation filtration, and alter pressure set points based on time (variable pressure settings)
- Selection of the full color touch screen and modem options provides communication between the pump station and central control computer
- Power-loss auto-restart ensures seamless operation on loss and regain of electrical power

DPX-Series Application

- Warm climate residential and commercial flooded-suction, pressure boosting, and suction lift irrigation applications up to 300 gpm, with pressures up to 150 psi requiring liquid cooled electronics
- When communication between the pump station and a Rain Bird's SiteControl is desired

DPX-Series Options

- Full color touch screen with Spanish and English operator screens. This option is required for communication between the pump station and central control computer
- Hard wire or radio communication modems
- Filtration or wye strainer with auto flush
- Self cleaning inlet screen
- Pump start relay
- "Z" pipe
- Lake level controls
- Pump bypass
- Enclosure heater
- Suction lift assembly

INTERMEDIATE FLOW PUMP STATIONS

Flows Up to 750 gpm (170 m3/h) at 120 psi (8,3 bar). Higher Flows Available at Pressures Less than 120 psi (8.3 bar)

- **Enhanced Serviceability** – Modern electrical design utilizing industrial breaker motor protection instead of time-wasting fuses. Industrial circuit breakers are quickly reset and designed for an extended service life
- **Easy Operator Training** – Easy to navigate monochrome touch-screen
- **Reduced Cost** – Our powder coat paint earned a perfect rating on STM corrosion tests. Less corrosion equals longer pipe, skid, and manifold life, reducing cost

Features

- Everything you need for your irrigation system construction or renovation from the only manufacturer dedicated to irrigation for over seven decades
- Easy installation and start-up

Application

Reliable variable frequency drive, single horizontal end suction pump stations designed for boosting pressure on golf course with elevation changes, lake transfer, or serving as the main irrigation pump station on smaller golf courses configured for flooded-suction or suction lift.

Options

- Air conditioner electrical panel cooling
- Enclosures: aluminum, painted steel (government specified colors), or stainless steel
- Full color touch-screen with English and Spanish
- Magnetic flow meter
- Modem, radio or hard-wired
- Totally enclosed, fan cooled (tefc) motor
- Wye strainer with auto back-flush
- Z discharge pipe

Electrical Power Specifications

- 60 Hz, 3-Phase Power: 230V (up to 60hp per pump), 460V, 575V
- 50 Hz, 3-Phase Power: 190V (up to 60hp per pump), 380V, 415V
- 60 Hz, 1-Phase Power: 230V (up to 30hp per pump)

WATER FEATURE PUMP STATIONS

Flows Up to 10,000 gpm (2,300 m3/h) and Greater

- Adjustable Look – The VFD allows for altering the look of a water feature by adjusting the pump run speed
- Save Energy – "Night-Run" Mode runs VFD driven pump at minimum speed, minimizing energy cost while preventing stagnant water
- Enhanced Serviceability – Modern electrical design utilizing industrial breaker motor protection instead of time-wasting fuses. Industrial circuit breakers are quickly reset and designed for an extended service life

Features

- Monochrome touch-screen operator interface
- Powder coat paint earned a perfect rating on ASTM corrosion tests. Less corrosion equals longer pipe, skid, and manifold life, reducing cost

Application

Reliable Variable Frequency Drive (VFD), water feature pump stations allow adjustable water feature appearance and provide a "Night-Run" mode that prevents stagnant water when the full look of the water feature is not desired. Constant speed systems require that the system be on or off, allowing water to stagnate during non-running periods. **Available in flows up to 10,000 gpm and greater in the following configurations:**

– Vertical turbine pump stations for wet-well applications
– Split-case and horizontal end suction for flooded suction applications

Options

- Air conditioner electrical panel cooling
- Custom controls
- Custom piping and manifolds
- Enclosures: aluminum, painted steel (government specified colors) or stainless steel
- Fabricated discharge heads
- Filtration: backwashing screen filters and suction scan filters (hydraulic or electric)
- Heater, skid mounted 5KW
- Intake box screen with 3 stainless steel screens
- Lake level control: float switch and ultrasonic
- Totally enclosed, fan cooled (TEFC) motors
- Wye strainer with auto back-flush
- Z discharge pipe
- Hdpe piping and manifolding

Electrical Power Specifications

- 60 Hz, 3-Phase Power: 230V (up to 60hp per pump), 460V, 575V
- 50 Hz, 3-Phase Power: 190V (up to 60hp per pump), 380V, 415V

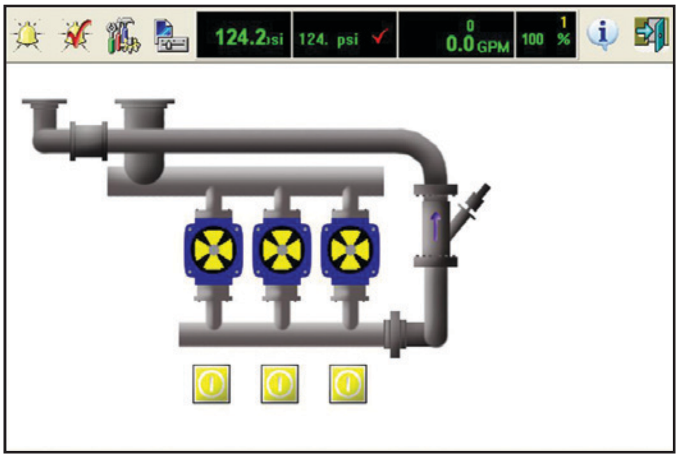
PUMP MANAGER WITH SMARTPUMP™

Combine a Rain Bird's Pump Station and Central Control Software to fully integrate pump station operation with your Central Control with real-time communication.

Pump Manager with SmartPump™

- Matches irrigation system operation with the real capacity of the pump station, shortening the water window and decreasing energy consumption
- Alerts the superintendent in real time of irrigation and pump station problems via cell phone text message
- Responds to irrigation system and pump system problems in real time. Other systems can lose an hour of irrigation time trying to recover from a fault

Pump Manager with SmartPump™ provides for pump station control and full monitoring capabilities from the Central Control.

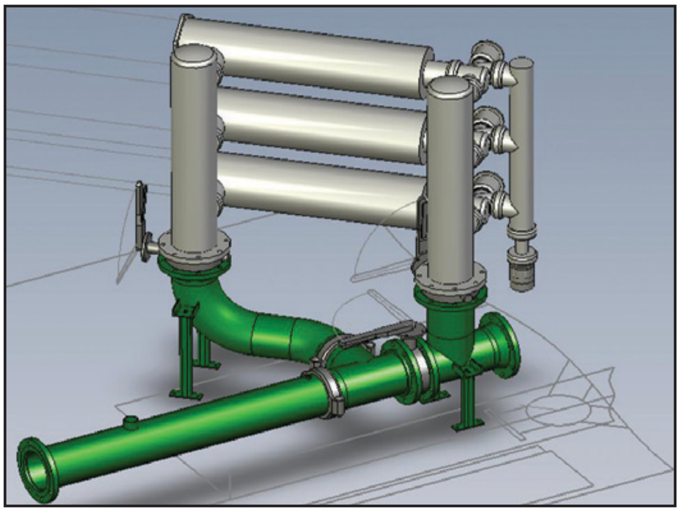


RAIN BIRD FILTRATION SYSTEMS

Need filtration due to lowering water quality or getting ready to switch to reclaim? Rain Bird can fabricate custom filter manifolds and integrate leading back-washing screen filters or suction-scan filters to yield a filter system that is ready to install.

Filter Systems are available for flows up to 10,000 gpm and available with:

- Backwashing screen filters with epoxy coated steel
- Hydraulic or electrically operated suction-scan filters in painted steel or stainless steel construction



Pump Station Service

Rain Bird fields a nationwide network of Authorized Service Providers to ensure your pump station remains in operation. Additionally, Rain Bird also offers Phone Support, Preventative Maintenance Plans and Full Service coverage during and after the Customer Satisfaction Policy is completed. Add these services to your purchase to get the full package. Contact your authorized Rain Bird Distributor for details.

PRESSURE CONVERSION

PSI	FEET	METER	BAR	kPa
1	2.3090	0.7038	0.0689	6.8948
80	185	56	5.5	552
85	196	60	5.9	586
90	208	63	6.2	621
95	219	67	6.6	655
100	231	70	6.9	689
105	242	74	7.2	724
110	254	77	7.6	758
115	266	81	7.9	793
120	277	84	8.3	827
125	289	88	8.6	862
130	300	91	9.0	896
135	312	95	9.3	931
140	323	99	9.7	965
150	346	106	10.3	1034
160	369	113	11.0	1103
170	393	120	11.7	1172
180	416	127	12.4	1241
190	439	134	13.1	1310
200	462	141	13.8	1379

FLOW RATE CONVERSION

GPM	ft^3/s	m^3/h	l/s	acre-ft/day
1	0.0022	0.2271	0.0002	0.004419
100	0.22	22.7	6.3	0.442
250	0.56	56.8	15.8	1.105
500	1.11	113.6	31.5	2.210
750	1.67	170.3	47.3	3.314
1000	2.23	227.1	63.1	4.419
1500	3.34	340.7	94.6	6.629
2000	4.46	454.2	126.2	8.838
2500	5.57	567.8	157.7	11.048
3000	6.68	681.4	189.3	13.258
3500	7.80	794.9	220.8	15.467
4000	8.91	908.5	252.4	17.677
4500	10.03	1022.1	283.9	19.886
5000	11.14	1135.6	315.5	22.096
6000	13.37	1362.7	378.5	26.515
7000	15.60	1589.9	441.6	30.934
8000	17.82	1817.0	504.7	35.353
9000	20.05	2044.1	567.8	39.773
10000	22.28	2271.2	630.9	44.192

HORSEPOWER TO KILOWATTS

HORSEPOWER	KILOWATT	HORSEPOWER	KILOWATT
1	0.746	25	18.7
3	2.2	30	22.4
5	3.7	40	29.8
10	7.5	50	37.3
15	11.2	60	44.8
20	14.9	75	56.0

LAKE INTAKE BOX SCREEN SIZING

FLOW RATE IN GPM	BOX SCREEN SIZE
0 - 500	LIBS - 18"
501 - 1000	LIBS - 24"
1001 - 1800	LIBS - 30"
1801 - 2800	LIBS - 36"
2801 - 4000	LIBS - 42"
4001 - 5000	LIBS - 48"
5001 - 7000	LIBS - 54"
7001 - 8500	LIBS - 60"
8501 - 10000	LIBS - 66"

Based on screen velocities of less than 0.5 feet per second

WET WELL INTAKE PIPE SIZING

FLOW RATE IN GPM	PIPE DIAMETER
0 - 500	14"
501 - 1000	18"
1001 - 1500	22"
1501 - 2000	24"
2001 - 2500	26"
2501 - 3000	30"
3001 - 3500	32"
3501 - 4000	34"
4001 - 5000	36"
5001 - 6000	42"
6001 - 7000	48"
7001 - 8000	48"
8001 - 9000	54"
9001 - 10000	54"

The pipe diameters listed in this chart assume a total equivalent pipe length of less than or equal to 200', smooth plastic pipe material (i.e. PVC or HDPE), and water velocities of less than or equal to 1.5 feet per second.

WET WELL OPEN AREA SIZING

SIZE	SHAPE	NUMBER OF PUMPS
36" DIA	ROUND	1 - Vertical Turbine
48" DIA	ROUND	1 or 2 - Vertical Turbines
60" DIA	ROUND	1 or 2 - Vertical Turbines
72" DIA	ROUND	1 to 3 - Vertical Turbines
84" DIA	ROUND	1 to 5 - Vertical Turbines
96" DIA	ROUND	1 to 6 - Vertical Turbines
6' X 8'	RECTANGULAR	1 to 7 - Vertical Turbines

FULL LOAD AMPERAGE (FLA)

MOTOR HP	SINGLE PHASE A-C		THREE PHASE A-C INDUCTION TYPE SQUIRREL CAGE & WOUND ROTOR		
	115 VOLTS	230 VOLTS**	230 VOLTS**	460 VOLTS	575 VOLTS
1/2	9.8	4.9	2.0	1.0	.8
3/4	13.8	6.9	2.8	1.4	1.1
1	16	8	3.6	1.8	1.4
1 1/2	20	10	5.2	2.6	2.1
2	24	12	6.8	3.4	2.7
3	34	17	9.6	4.8	3.9
5	56	28	15.2	7.6	6.1
7 1/2	80	40	22	11	9
10	100	50	28	14	11
15			42	21	17
20			54	27	22
25			68	34	27
3			80	40	32
40			104	52	41
50			130	65	52
60			154	77	62
75			192	96	77
100			240	120	96
125			296	148	118
150			350	175	140
200			456	228	182
250			558	279	223

***For 208V applications, increase the FLA by 10%*

To calculate the FLA of a pump motor operating on a VFD, multiple the nominal FLA by 1.24

To estimate FLA, multiple the largest load by 1.25 and then add this to remaining component FLAs.

Example: a 460V 2 x 50HP pump station with a 5HP PM pump would have an FLA of 173.4 Amps.

173.4 Amps = 1.24x1.25x65A + 65A + 7.6A

The Intelligent Use of Water.™

LEADERSHIPS • EDUCATION • PARTNERSHIPS • PRODUCTS

At Rain Bird, we believe it is our responsibility to develop products and technologies that use water efficiently. Our commitment also extends to education, training and services for our industry and our communities.

The need to conserve water has never been greater. We want to do even more, and with your help, we can. Visit www.rainbird.com for more information about The Intelligent Use of Water.™

Rain Bird Corporation
6991 E. Southpoint Road
Tucson, AZ 85756
Phone: (520) 741-6100
Fax: (520) 741-6522

Rain Bird Technical Services
(800) RAINBIRD (U.S. and Canada)

Rain Bird Corporation
970 West Sierra Madre Avenue
Azusa, CA 91702
Phone: (626) 812-3400
Fax: (626) 812-3411

Specification Hotline
800-458-3005 (U.S. and Canada)

Rain Bird International, Inc.
P.O. Box 37
Glendora, CA 91740-0037
Phone: (626) 963-9311
Fax: (626) 852-7343

www.rainbird.com

D37457