

EQUIPMENT AND WATER SUPPLY CHANGES PRODUCE INCREASED EFFICIENCY AND NUT YIELDS

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ABSTRACT

Pioneer Ranch Partnership LLC operates an 80-acre almond ranch in the Turlock Irrigation District (TID) in Central California. Ground water from two wells has been applied with Rainbird sprinklers. The lower tree canopies are wetted with Rainbirds and canker disease frequently develops. Ground water requires buffering with acid to offset carbonates.

Irrigation improvements were made in stages. First, Rainbird sprinklers were replaced with micro sprinklers at each tree. A filter was installed at each well. The second stage included a single central pump at the TID pipeline on the Ranch with pipelines to each well and hookup to the filters and micro sprinkler lines. The 75-HP well motors and pumps were kept operable for frost control and for backup supply in water short years.

A single 75-HP pump for surface water is adequate to supply all low-pressure micro sprinklers. Irrigation labor has been reduced by 50 percent. The seasonal water applications with micro sprinklers during 2009 and 2010 were 135 acre-feet and 175 acre-feet, respectively. For an average of 155 acre-feet this was a reduction of about 33 percent. Electricity use was reduced from 61,000 KWH to an average of 16,180 KWH for 2010 and 2011. It is no longer necessary to buy “risk-handling” acid. The annual loss of 40 diseased trees will be avoided. Tree foliage looks significantly healthier. It is estimated that there will be a 10 percent increase in nut yield.

The capital cost was about \$86,000. Based on 6 percent interest, reduced operating costs and increase in yield, the capital cost can be recovered in less than three years.

INTRODUCTION

Using ground water for irrigation provides significant flexibility in scheduling applications-both seasonally and daily. When its use involves some unique management issues and anticipated increase in the cost of power, as was the case for Pioneer Ranch, it became prudent to examine the merits of switching to surface water which is available from Turlock Irrigation District (TID). Annual water assessments were already being paid and the Ranch is entitled to buy TID water. This paper describes the factors which were evaluated and the benefit-cost analyses which led to changes in facilities and water use.

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ALMOND CULTURE

Almonds are a major tree crop in California which produced about 1.17 billion pounds from 705,000 acres in 2010. Production increased 23 percent to 1.44 billion pounds in 2011. Stanislaus County, in which Turlock Irrigation District and Pioneer Ranch are located, had about 97,600 acres or 14 percent of the total acreage in 2010. Almond trees bloom in February-March and are harvested in August-September depending on the variety. Damaging frosts can occur during the bloom. Honey bees for pollination, 160 hives for Pioneer Ranch, and irrigation water are two key inputs for successful crops. Almonds are harvested by mechanical shaking of the entire tree when the hulls have opened. The nuts, mostly still in the hulls, are swept into windrows and then loaded onto trucks for a trip to the huller. The hulls are first removed and then the nuts are passed through a cracker where meats (kernels) are separated from the shells. The nuts are then shipped to the processor--in our case Blue Diamond Growers. Almond hulls, which have about two-thirds of the nutrient value of alfalfa, are sold for incorporation into dairy cow feed.

Almond trees reach full production in about 8-10 years and begin to decline after about 20 years. They are usually replaced after about 25 years depending on the benefit/cost comparisons. Tree spacings are becoming smaller as more tailored equipment and management have improved yields. Trees on Pioneer Ranch are on 22-foot centers or 90 trees per acre.

RANCH DESCRIPTION

The 80-acre Ranch is the south half of a quarter section. The deep soils are generally sandy silts with good drainage and are ideal for tree crops. Half of the trees were replanted in 2000 and the other half in 2004.

A 36-inch gravity pipeline of TID passes through the center of the Ranch in a westerly direction. A 16-inch well is located at the center of each half of the Ranch. The pumping lift is about 140 feet.

Vandalism and copper theft are big problems on farms throughout the Central Valley and the Ranch has had its share. Well sites and equipment have been enclosed in security fencing with motion sensors which are monitored on a 24-hour basis. Rainbird sprinkler heads have been used as "bowling pins" for dirt bike riders. There is no one in residence on the Ranch and the perimeter is now fenced.

IRRIGATION PRACTICE ON PIONEER RANCH

The first seasonal irrigation on Pioneer Ranch is generally in April. Actual timing depends on the amount of winter rainfall and the moisture available in the tree root zone as shown from soil moisture sensors. In 2012, due to the lack of rain, trees were irrigated in January. The last irrigation is generally after harvest in late October.

Until 2010 Pioneer Ranch was irrigated with ground water from two wells. Prior to 2009 water was applied with Rainbird sprinklers. These sprinklers covered most of the land surface and wetted the lower tree canopies. Canker disease developed in some of the trees. It is a particular problem in young trees. Excess moisture on the trees also creates problems with hull rot.

The ground water at the Ranch is quite high in carbonates and requires addition of acid for neutralization. Liquid NpHURIC, a formulation of urea and sulfuric acid, was used. (The technical name for the formulation is dicarbamide dihydrogen sulfate solution.) Special care must be taken in handling the acid and there is always a risk of injury to a worker.

CHANGES IN IRRIGATION PRACTICE

The primary water management concerns were the canker disease problem and the less than fully effective application of water from Rainbird sprinklers to areas beyond the tree root zone. Rainbird sprinklers were replaced with micro sprinklers at each tree. It was also necessary to install filters at each well as some sand was pumped from the wells and micro sprinklers would become clogged. There was a significant reduction in use of power for pumping with lower pressure requirements of the micro sprinklers and less water application. There was also less drawdown in the wells with lower rates of water application.

The second step was conversion from ground water to surface water from the TID pipeline. A single pump with a 75-HP motor was installed and a totalizing flow meter was placed in the discharge line. Pipelines about 330 feet long were constructed to connect with equipment at each of the well sites. Water from the TID pipeline comes from a canal and it was necessary to construct a turnout box with a moss screen. The filters at the wells have a continuous discharge of about 100 gallons per minute (gpm) of filtrate that is conveyed in a 2-inch pipe to the TID pipeline downstream of the Ranch. This avoids ponding and interference with farm operations near the well sites and also results in no waste of water from the filters.

The existing well equipment was retained for back-up water for frost protection in the spring when the trees are in bloom and nuts are forming. Water from the sprinklers adds heat to the tree environment which can be enough to prevent frost damage if it does not freeze too hard. The wells also are available for post-harvest irrigation in dry years if TID does not have enough water. Switching for electric power service is arranged so that only the central surface water pump or the two wells can be operated at any one time. It is thus possible to avoid paying for increasing the connected load above that of the two pumps. The pumps will be operated annually to ensure water will be available when needed, particularly for frost control.

In accordance with public health regulations and for prudent management of the wells, a self-closing check valve was installed at each well to prevent surface water from entering

the well. It is possible, however, to pump ground water into the TID pipeline, if needed by TID to serve downstream users in critically dry years.

Use of micro sprinklers makes it possible to irrigate all of the Ranch at one time. However, with micro sprinklers it is necessary to irrigate one or two times more each season than with Rainbird sprinklers. The Ranch operator's headquarters are about seven miles away from the Ranch and there are significant savings in travel time for workers to check on irrigation equipment. By being able to irrigate all of the ranch at one time, there are net savings in labor hours with the use of micro sprinklers.

Power requirements are much lower using surface water because micro sprinkler pressures are lower and it is not any longer necessary to pump ground water to the land surface. During years when Rainbird sprinklers were used the seasonal application of water was about 36 inches or 240 acre-feet. With micro sprinklers the amount of applied water was 135 acre-feet in 2010 and 175 acre-feet in 2010 for an average of 155 acre-feet or nearly 24 inches of water.



New Pump and Turnout/Moss Screen Box



950-GPM Filter Connected to Both A Well and TID Water

CAPITAL COSTS

Design and construction was provided by Waterford Irrigation and Supply, Inc., a local consulting firm. Work was scheduled and managed by the Ranch operator, Piazza Farms, to fit in with irrigation and ranch operations.

Stage 1 work, replacement of Rainbird sprinklers with micro sprinklers and filters at the wells, was completed in 2009. Stage 2 work, construction of the central surface water pumping plant, power supply and pipelines to the two well sites, was completed in 2010. The cost of each stage is shown in the following tabulation:

Costs of Installed Equipment

Item	Stage 1	Stage 2
Micro sprinklers	\$19,510	
Two 950-gpm, 8-inch filters	26,640	
75HP Pump		\$8,740
Pump and Appurtenances Installation		21,700
Electrical Controls Installation		8,050
Totals	\$46,150	\$38,490

SAVINGS AND BENEFITS

There are both quantifiable and qualitative benefits from conversion from ground water to surface water.

Power

Power savings may be measured by the reduction in energy use. The connected load billed by TID remains the same as with ground water use because, while the two well motors remain on line for backup water, controls at the surface water pump prevent concurrent operation with the well pumps.

Energy use in 2008, when Rainbird sprinklers were still used with wells, was 61,440 KWH. In 2010 the use was 14,120 KWH and in 2011 it was 18,240 KWH. With an average post-project use of about 16,000 KWH, there will be a reduction of about 45,000 KWH per year or approximately a 75 percent saving.

TID connected load and energy charges vary by season. Charges are \$0.0716/KWH and \$1.66 per connected HP during March-October and \$0.1654/KWH and no load charges during November-February. The average unit cost for energy used on the Ranch in 2011, including public benefits adjustments and state surcharge, was \$0.0923/KWH. This rate represents savings of about \$4,150 per year for 45,000 KWH.

Water Quality

With surface water for irrigation it is no longer necessary to buy acid to neutralize the carbonates in ground water. The average cost of acid in 2008 and 2009 was about \$8,000.

The future loss of trees due to canker disease can be estimated by the rate of loss over eight years prior to the use of micro sprinklers. The loss from 3,500 trees planted in year 2000 was about 20 trees per year. This rate would result in an annual loss of 40 trees for the entire Ranch. Based on insurance payments for trees lost in accidents the value of each producing tree is about \$150. For an average annual loss of 40 trees this is equivalent to \$6,000 per year.

Water Cost

In addition to annual assessments on land in TID there is a charge for delivered water. For Pioneer Ranch the charge in 2011 was \$2,070.

Labor for Irrigation

Irrigation labor when Rainbird sprinklers were used required about four hours for each turn-on and turn-off for each well. With an average irrigation interval of 15 days over eight months the total labor is slightly over 260 hours. The average cost of labor is \$12.00 per hour for a total cost of \$3,120 per season.

Micro sprinklers reduce the number of hours per irrigation from 16 to 8 but increase the frequency from 15-day intervals to 10-day intervals. Over eight months there will be 16 irrigations requiring a total of 128 hours at a cost of \$1,540 resulting in saving \$1,580 per season.

Nut Yield

Specific quantitative data on increases in nut yields resulting from more uniform application of water and the high quality of surface water from the Tuolumne River are not identifiable because the trees were maturing and increasing in yield during the changes in equipment. The Ranch Operator, who operates several ranches and hundreds of acres of almonds, conservatively estimates that there will be a 10 percent increase in yield. The tree foliage looks healthier than when ground water was used.

One-half of the trees are at full production at eleven years of age. The other half are seven years old and are not up to full production. The Ranch produced 143,00 pounds and 141,000 pounds of good meats in 2009 and 2010, respectively. Based on 10 percent attributable to better water applied more efficiently the increase was 14,000 pounds. At full tree maturity of all trees, an increase of 15,000 pounds is a conservative estimate. The current payment rates for Ranch varieties are about \$1.90 per pound resulting in an estimated benefit of \$28,500 per year.

ECONOMIC ANALYSIS

The foregoing costs and savings/benefits are summarized as follows:

Capital Improvements	
Stage 1	\$46,150
Stage 2	<u>38,490</u>
Total	\$85,540

Annual Savings/Benefits and Costs

Avoided acid purchase savings	\$8,000
Power savings	4,150
Reduced irrigation labor costs	1,580
Reduced loss of diseased tress	6,000
Increase yield of nuts	28,500
Water charge	<u>(2,070)</u>
Total	\$46,160

A valid economic evaluation requires that costs and benefits be based at the same point in time. Using costs at the time of construction requires that future savings/benefits be based on present worth. It is also necessary to include the cost of future maintenance of equipment. It is conservatively estimated that annual maintenance costs would not exceed five percent of the capital cost during a 20-year equipment life-evaluation period. This allowance would be about \$4,300 per year.

The following tabulation shows present worth of costs and net savings/benefits based on six percent interest over a 20-year period:

Capital costs	\$85,540
Maintenance	<u>49,320</u>
Total present worth of costs	\$134,860
Present Worth of Net Savings/Benefits	\$529,460

The foregoing values indicate a benefit-cost ratio of 3.9:1. It is recognized that about 75 percent of the benefits are in the estimated 10 percent increase in nut yields. However, even if the increase is only five percent, the benefit-cost ratio would be 2.7:l.

The estimated annual savings/benefits of \$46,160 indicates that, conservatively, the capital costs of \$85,540 will be recovered in less that three years, even if there is any abnormal spring weather.

SUMMARY

The loss of newly planted trees from canker disease, the costs and risks of buying and handling acid and the anticipated increase in power rates caused re-thinking of continued use of ground water. (TID did raise power rates about 20 percent beginning in 2009.) Tree disease and the cost of power were first addressed by switching from Rainbird sprinklers to micro sprinklers. The availability of high quality surface water and power through the center of the Ranch provided a unique opportunity to modify the irrigation equipment and cease use of acid for neutralization of carbonates in ground water.

The ability to draw on two sources of water provides flexibility and enhances the value of the Ranch. An agricultural land appraiser opined that the increase in value would be at least as great as the capital cost inasmuch as a new owner would need to invest a like amount to achieve comparable flexibility and supply assurance.

The ability to irrigate all of the Ranch at one time reduces the time requirements and attention of the Ranch manager as well as the irrigation labor costs.

An additional, but difficult to quantify in terms of the timing and amount, will be savings from delay of well pump and motor repairs which can be quite expensive.

Developed water supplies in California are not enough to meet needs even in years with normal precipitation. Priorities for environmental goals in some situations are higher than for agricultural supplies. Increasing attention is being focused by the State legislature and the State Water Resources Control Board, which issues and manages surface water rights permits, on ground water use and rights. The retained ability to pump ground water will allow the Ranch to forego its surface water in extremely dry years when TID may need to ration water. Such return to ground water will free-up water for other users.

The changes on Pioneer Ranch have been noted by other almond growers who have similar water supply situations. It is expected that others will follow the Pioneer Ranch LLC example.