# AGRICULTURAL WATER USE SURVEY AND REPORT

# BORREGO VALLEY, CA

Prepared for the Agricultural Alliance for Water and Resource Education (AAWARE)

December, 2003

by

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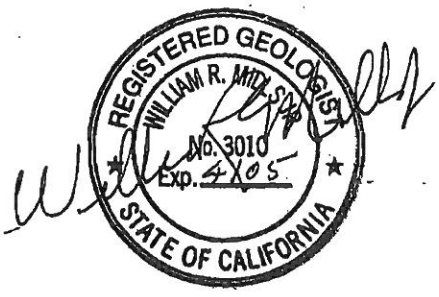


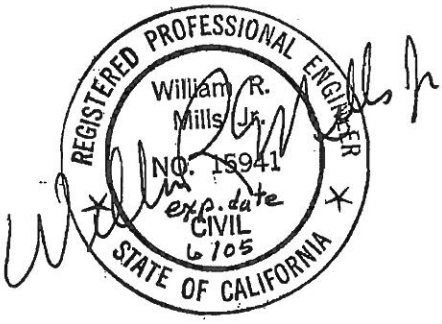


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## 1.0 Introduction

Groundwater levels in the Borrego Valley have shown a continuing lowering since the 1960s. This trend is an indication that the extractions from the aquifer exceed the recharge to the aquifer. Several attempts at quantifying the amount of imbalance between extraction and recharge have been made. These involve developing estimates of the extractions and recharge. Extractions for residential and commercial uses are generally metered while those for golf course and agricultural uses are not. Two indirect measurement methods exist. These include: (1) estimation from land use and water delivery knowledge and (2) estimation from power records.

Estimates of agricultural water use have been made by the first method, including the Bureau of Reclamation, Department of Water Resource, United States Geological Survey, a California State University of San Diego Masters' Thesis and by the Borrego Water District (BWD) Ground Water Management Plan (AB3030).

This method involves the use of aerial photographs and estimates of the water delivery for individual crops. Aerial photographs must be interpreted to determine the type of crop for each area identified. Additionally, the acreage devoted to each crop must also be scaled or otherwise determined from the photograph. Finally, estimates of water use for delivery and consumption by each type of crop must be made. Delivery use rates for various crops vary depending on the solar radiation, temperature, etc. and also vary from one area to another across the State of California.

A more accurate method of assessing unmetered delivery amounts for agricultural water use is with data developed from pumping well power records and from tests that define the amount of water extracted by the well for each unit of power used by the well motor. These tests are conducted by an independent testing company and are used by the irrigator to identify efficiency declines. With this knowledge, the irrigator can perform well maintenance, repair or make other modifications to improve well efficiency and reduce power consumption at the facility. An example of such a test is attached.

While it is important to define the amount of water delivered to agriculture, it is more important to determine the amount of the delivered water that is consumptively used by the crop and is lost to evapotranspiration (ET) because the amount of delivered water in excess of the crop's ET percolates back into the aquifer for subsequent use. Consumptive use or ET rates for various crops are specific for geographical areas and have been studied by the University of California for many years. A more recent development is the State's CIMIS (California Irrigation Management Information System). This system provides internet accessible hourly, daily and monthly information concerning the consumptive use or evapotranspiration of plants. A CIMIS station is located near the Borrego Valley.

## 2.0 Prior Study Results

The most recent estimate of the amount of water extracted for agricultural use in the Valley was prepared by the Borrego Water District. The District's recent Ground Water Management Plan estimated the water delivered to agriculture at 15,590 acre-feet-per-year (afy), but did not estimate the net extractions. A Master's thesis estimated the net water extracted for agriculture at 9,540 for the year 2000. This report estimates both the gross (pumped) and the net amount of extracted water.

## 3.0 Survey Methodology

Recognizing that prior estimates of agricultural water use were performed using the aerial photograph method and without the direct involvement of the agricultural community, AAWARE undertook the task of estimating the water use by the agricultural community. It was decided that a survey conducted using individual grower information regarding power consumption and irrigation methods, would provide a more accuracy assessment of water use from the northern area of then Valley. Further, the study results would be useful in verifying prior estimates of the application rates for various crops. It was also envisioned that the study could identify the irrigation techniques currently used for the purpose of demonstration the water conservation efforts employed by the irrigators.

A survey questionnaire form was developed and provided to each member of AAWARE for completion. The completed form was returned to AAWARE's attorney to maintain confidentially of the data. AAWARE's professional engineer and registered geologist reviewed the data and made individual checks for anomalies or incorrect responses. The data set was then aggregated into usage by crops type, age of crop and by irrigation methods. From these data, a gross agricultural water use estimate was developed. Other useful information regarding crop types and irrigation methods were also obtained.

The questionnaire is attached. The data provided by the respondents was for the calendar year 2002.

## 4.0 Agricultural Acreage in the Valley

The total acreage encompassed by this survey included about 5,100 acres. About 95% of this acreage is represented within the AAWARE organization. About 88% of the irrigated acreage was reported by the survey questionnaire. The water use in non-reporting areas, including the non-AAWARE acreage, was estimated based on local knowledge.

### 4.1 Irrigated Acreage

The survey showed that about 3,400 acres were irrigated and approximately 1,700 acres were fallow. The following tabulation shows the amount of acreage devoted to each crop:

| Crop Type | Acreage |
|---|---|
| Citrus | 2,340 |
| Palm Trees | 510 |
| Truck | 250 |
| Other | 295 |
| Total | 3,395 |

In general, the crop type 'Other' included nursery, cactus, herbs and various fruit trees. As shown above, the predominant crop is citrus followed by palm tree. Prior reports have estimated the acreage under cultivation in the Valley at about 3,550 to 4,000 acres.

### 4.2 Irrigation Methods and Irrigation Efficiency

The method of applying water to crops is important as some methods result in excessive evaporation during irrigation. The most commonly used irrigation techniques were found to be drip and micro spray. These two efficient application methods were used on 85% of the irrigated acreage.

| Irrigation Method | Acreage |
|---|---|
| Drip and Micro spray | 2,915 |
| Pivot Center, Sprinkler and Flood | 480 |
| Total | 3,395 |

Drip irrigation was favored for young citrus trees, but the greater coverage provided by micro spray was necessary for mature trees.

It was noted that some growers reported that they schedule irrigation events and amounts using real time CIMIS data as discussed later. Further, the use of tensiometers, installed at depths between 12 and 36 inches below ground surface, are used by some growers to determine crop irrigation events.

## 5.0 Extracted Water

The survey technique for determining the amount of water extracted and delivered to various crops utilized power records and well production information for the most part. However, it was necessary to check the information for accuracy. Thus, water production data derived from power records was compared to the irrigated acreage to develop a unit value for water delivery. (Unit values are defined as the depth of water, expressed in feet, spread over a unit area. For example, the amount of water expressed in acre-feet spread over one acre of irrigated land.) This value was then checked against referenced unit values.

The California Department of Water Resources (DWR) has developed the delivery (applied) values for crops in the Borrego Valley as shown in Table 1. (The DWR data were incorporated in the background data for the DWR publication Bulletin 160-83

relating to Borrego Valley.) The DWR data for the two most common crops grown in the Valley are shown in Table 1.

**Table 1 Unit Values for Water Use (ft)**

| Type of Crop | Consumptive (ET) Unit Use | Applied Unit Use | Irrigation Return Unit Use |
|---|---|---|---|
| Citrus | 3.8 | 5.4 | 1.6 |
| Tree Farm | 2.0 | 2.9 | 0.9 |

The AAWARE information allowed the calculation of the delivered unit values for each grower and for citrus and tree farms (palms). It should be noted that the delivery unit values were found to vary according to grower, irrigation method and age of crop. For example, the delivery unit values for drip and micro sprinkles were less than those for less efficient irrigation methods such as flood. Further, crop age was also a factor. Mature crops were delivered more water per unit area than the young crops

Calculated delivered unit values for citrus were found to vary from about 5.0 to 5.6 ft as compared to the DWR value of 5.4 as shown in Table 1. Delivered unit values for palms was about 2.0 to 2.5 ft as compared to the 2.9 value of DWR. When calculated unit delivery values were inconsistent with published data and with those calculated for other growers, the energy production method was abandoned and unit values consistent with other information was used to develop the delivered quantities.

A total of about 14,700 af was determined to be extracted and applied to the irrigated acreage within the Valley (See Section 6.0). This amount is less than that derived by the BWD. This is due to the BWD use of a delivery unit value for citrus of 6.0 and 4.0 for palms.

## 6.0 Net Water Use

Table 1 also displays the DWR estimates of the consumptive or ET loss by each of the two crops shown. For example, the ET for citrus is estimated at 3.8 ft while the delivery amount to shown at 5.4 ft. The delivery amount must be greater than the ET in order to to maintain the salinity within the root zone at below levels that are not harmful to the crop. As a consequence, the grower applies more than the ET amount to ensure full production from the crop. If subsurface hydrogeologic conditions are favorable, the over supply of delivered water is returned to the groundwater basin for subsequent use.

### 6.1 Evapotranspiration of Crops

The ET of agriculture in the Valley could be estimated using the values for consumptive use developed by DWR and shown in Table 1. However, more recent technological advancements allow more accurate determinations.

The DWR has established and now maintains more than 100 California Irrigation Management Information System (CIMIS) stations throughout the state. These stations provide real time information on evapotranspiration (ET) of turf grass. Though the use of individual coefficient for specific crops, the ET of turf grass can be converted to ET for specific crops. CIMIS Station 136 located in Oasis, CA (Imperial/Coachella Valley) provides internet accessible real time information on ET. Table 2 shows the long term average evapotranspiration by month at the station.

Table 2 Long Term Average Evapotranspiration at CIMIS Station 136 - Oasis – Imperial/Coachella Valley (inches)

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.44 | 3.31 | 5.25 | 6.85 | 8.67 | 9.57 | 9.64 | 8.67 | 6.85 | 5.00 | 2.95 | 2.20 | 71.40 |

As indicated, table 2 ET information is for grass. However, these data can be converted to ET values for other crops, using crop specific coefficients. CIMIS reference materials describe and present a coefficient for desert citrus of 0.6. The coefficient is multiplied times the ET for grass to obtain ET for citrus. Using the coefficient, the annual ET for citrus in the Borrego Valley is estimated at 42.8 inches or 3.6 feet per year. This value is slightly lower than the unit value presented in Table 1 of 3.8 feet per year. It is assumed that the CIMIS data from the Oasis Station, which became operational in 1997, being based on daily field measurements of ET, is more representative than the 1983 estimate and will be used in this report for estimating ET of various crops.

**6.2 Irrigation Return Flow**

As previously stated, the delivered or extracted water amount must be sufficient to satisfy the consumptive or ET need of the crop (without a reduction in yield) and to satisfy the leaching requirements. Thus, a portion of the delivered water is returned to the groundwater basin as commonly referred to a 'irrigation return' flow. The Irrigation Return Unit Use values shown in Table 1 are the difference between the Consumptive and Applied Unit Use values shown in the table.

The maintenance of soil salinity is referred to as the leaching requirement and defined as the minimum amount of irrigation water supplied that must be drained through the root zone to control soil salinity at the given specific level. The leaching requirement varies according to crop type, soils, annual precipitation and quality of the delivered water.

Estimates of the leaching requirement have been made by prior investigators. The DWR estimates the requirement at about 30% of the delivered water. More recently, a field study was conducted in the Borrego area. This study determined the leaching amounts for a citrus crop by comparing the salinity of water contained in the root zone to that of the delivered water. The study concluded that the leaching component was about 22% of the water delivered to the citrus crop. (The study also, using field data, determined that

the irrigation return percentage at the De Anza Golf Course was 14% of the delivered water).

An estimate of the return flow could be made using a percentage of the delivered water. This would not be appropriate, since not all irrigators use the same irrigation technique or apply the same amount of water. An alternative method is to determine the difference between the ET requirement for each crop type and the amount of water delivered to each crop. This is appropriate since the consumptive use unit values for each crop type should be about the same, except for the maturity component.

The irrigation return amount was computed for each grower and crop, based on their reported delivery rate and the known ET value for the crop. For example, if a grower reported an application rate of 5.0 ft/ac for citrus, the ET value as reported by CIMIS (Oasis) was deducted to obtain the return flow amount. In this case, the amount is 5.0-3.6= 1.4 ft/ac. This value was multiplied by the number of acres of production reported by the grower. If a grower reported an application rate of 5.7 then the return flow amount would be 5.7-3.6 or 2.1 ft/ac times the acreage.

A CIMIS crop coefficient for converting turf grass to palm trees could not be found, therefore the consumptive use value of 2.0 as determined by DWR and shown in Table 1 was used.

Since the crop category of 'Other' included a variety of crops, ranging from herbs to nursery, it was not possible to use the same methodology for determine ET and return flow. For this category, it was assumed that 20% of the delivery water would provide adequate leaching and therefore, the ET for the category would be 80% of the delivered amounts.

The following table shows the ET, delivery and irrigation return amounts for each crop type.

| Crop Type | Delivered Water | Evapotranspiration | Return Flow |
|---|---|---|---|
| Citrus | 11,100 | 7,750 | 3,350 |
| Palms | 1,750 | 1,250 | 500 |
| Other | 1,800 | 1,450 | 350 |
| Total | 14,650 | 10,450 | 4,200 |

As indicated above, the net water use is estimated at about 10,500 af. This value compares to the value published in the recent Master's thesis of 9,540 af. Considering the differences in methodology used in these developing these estimates, it is concluded that the results are comparable.

## 7.0 CONCLUSIONS

The study provided useful information that allows the following conclusions:

1. An individual questionnaire study is an effective means of collecting water usage information when water production is unmeasured. This is especially true when grower's wells have been tested for power production efficiencies and power records are available.

2. The growers in the Valley are employing the most effective irrigation application techniques available. About 85% of the irrigated acreage is irrigated by either drip or micro spray methods.

3. Some irrigators are employing 'best management' practices for irrigation scheduling and quantification. Techniques employed are tensiometers and CIMIS data.

4. The predominant crop grown in the Valley is citrus. About 2/3's of the irrigated acreage is devoted to citrus.

5. Approximately 14,700 acre feet of water is extracted and applied to the irrigated lands each year.

6. About 4,200 acre feet of the applied water is in excess of the individual crop evapotranspiration requirement and is returned to the groundwater basin. Thus, the net withdrawal is about 10,500 acre feet each year.

## 8.0 REFERENCES

California Department of Water Resources, Vegetative Water Use in California, Bulletin No. 113-3, 1974.

Ibid, The California Water Plan, Projected Use and Available Water supplies to 2010, Bulletin 160-83, December 1983.

Food and Agriculture Organization of the United Nations, Crop Water Requirements, Irrigation and Drainage Paper 24, 1984.

Netto, Steven, Water Resources of the Borrego Valley, San Diego County, California. Master's Thesis, San Diego State University, 2002.

# BORREGO VALLEY AGRICULTURAL WATER USAGE SURVEY, April 2003

FARM: _____

RESPONDENT: _____

PHONE NUMBER: _____

PART A – ANNUAL WATER USAGE

| WELL DESIGNATION | TOTAL HOURS RUN IN YEAR | WELL PRODUCTION RATE (gallons per minute) | TOTAL WATER IN YEAR (gallons) |
|---|---|---|---|
| | | | |
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| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

PART B – WATER USE EFFECIENCY

| CROP TYPE | AGE (years) | ACREAGE | IRRIGATION METHOD | APPLICATION RATE (feet per year) |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
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# PUMP CHECK

Pumping Systems Analysts

Hydraulic Test Report

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Test Date: 10/14/02
Plant: Diesel
Lat/Lon:

A test was made on this deep well turbine pump and the following information was obtained.

## EQUIPMENT

| | | | |
|---|---|---|---|
| PUMP: | No data | SERIAL: | n/a |
| ENGINE: | Cummins | SERIAL: | |

## TEST RESULTS

| | TEST 1 |
|---|---|
| Discharge, PSI | 34.5 |
| Discharge head, feet | 79.7 |
| Standing water level, feet | 275.9 |
| Drawdown, feet | 13.4 |
| Pumping water level, feet | 289.3 |
| Total pumping head, feet | 369.0 |
| **Gallons per minute flow** | **802** |
| Gallons per foot of drawdown | 59.8 |
| Acre feet pumped per 24 hours | 3.543 |
| Fuel, gallons per hour | 5.284 |
| Thermal H.P. | 290.6 |
| *Estimated BHP* | 104.9 |
| Measured speed of engine, RPM | 1718 |
| Measured speed of pump, RPM | 1718 |
| Gallons of fuel per acre foot | 35.8 |
| **Overall Plant efficiency in %** | **25.7** |
| *Estimated pump efficiency in %* | 71.2 |

Test 1 was the normal operation of the pump at the time of the test.

If you have any questions plewase contact Jon Lee at (909) 684-9801.

# PUMP CHECK

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Test Date: 10/14/02
Pump type: DWT
Plant:

A test was made on this well pump and the following information was obtained.

## EQUIPMENT

| | | | |
|---|---|---|---|
| PUMP: | Peerless | SERIAL: | |
| MOTOR: | GE | SERIAL: | |
| H.P. | 75 | LAT/LON: | |
| METER: | 1569821 | | |

## TEST RESULTS

| | TEST 1 |
|---|---|
| Discharge, PSI | 28.0 |
| Discharge head, feet | 64.7 |
| Standing water level, feet | 292.9 |
| Drawdown, feet | n/a |
| Pumping water level, feet | n/a |
| Total pumping head, feet | n/a |
| **Gallons per minute flow** | **661** |
| Gallons per foot of drawdown | n/a |
| Acre feet pumped per 24 hours | 2.921 |
| KW input to motor | 73.2 |
| HP input to motor | 98.0 |
| Motor load, % BHP | 117.6 |
| Measured speed of pump, RPM | 1771 |
| KWH per acre foot | 601.0 |
| **Overall Plant efficiency in %** | **n/a** |

Due to an obstruction in the well at 293', we were unable to obtain a pumping water level; therefore we were unable to quote the total head or overall efficiency of the pumping plant.

If you have any questions please contact Jon Lee at (909) 684-9801.