

# **Agriculture Water Use Technical Memorandum**

## **Eel River Valley Groundwater Basin**

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**Appendix 1 - Ferndale Monthly Rainfall Totals (October 1963-September 2021)**

# 1. Introduction

This technical memorandum develops an estimate of groundwater use for agricultural irrigation within the Eel River Valley Groundwater Basin (ERVB) utilizing representative monitoring data collected from eight flow meters in 2021. This memorandum was prepared to support development of the Groundwater Sustainability Plan (GSP) for the ERVB. The estimate for total irrigation groundwater use within the basin is based on:

1. An inventory of irrigated lands and the associated irrigation methods (Section 2).
2. Classifications of water year types for a 30-year period (1992-2021) using local rainfall data (Section 3).
3. Estimates of irrigation season duration based on water year type (Section 3).
4. Monitoring data collection and analysis (Section 4).

This memorandum includes a discussion regarding uncertainty in estimating irrigation water use (Section 5) and provides an estimate of groundwater use for dairy nutrient management (Section 6). Finally, the memorandum provides a comparison with previous irrigation groundwater use estimates using alternative methods (Section 7).

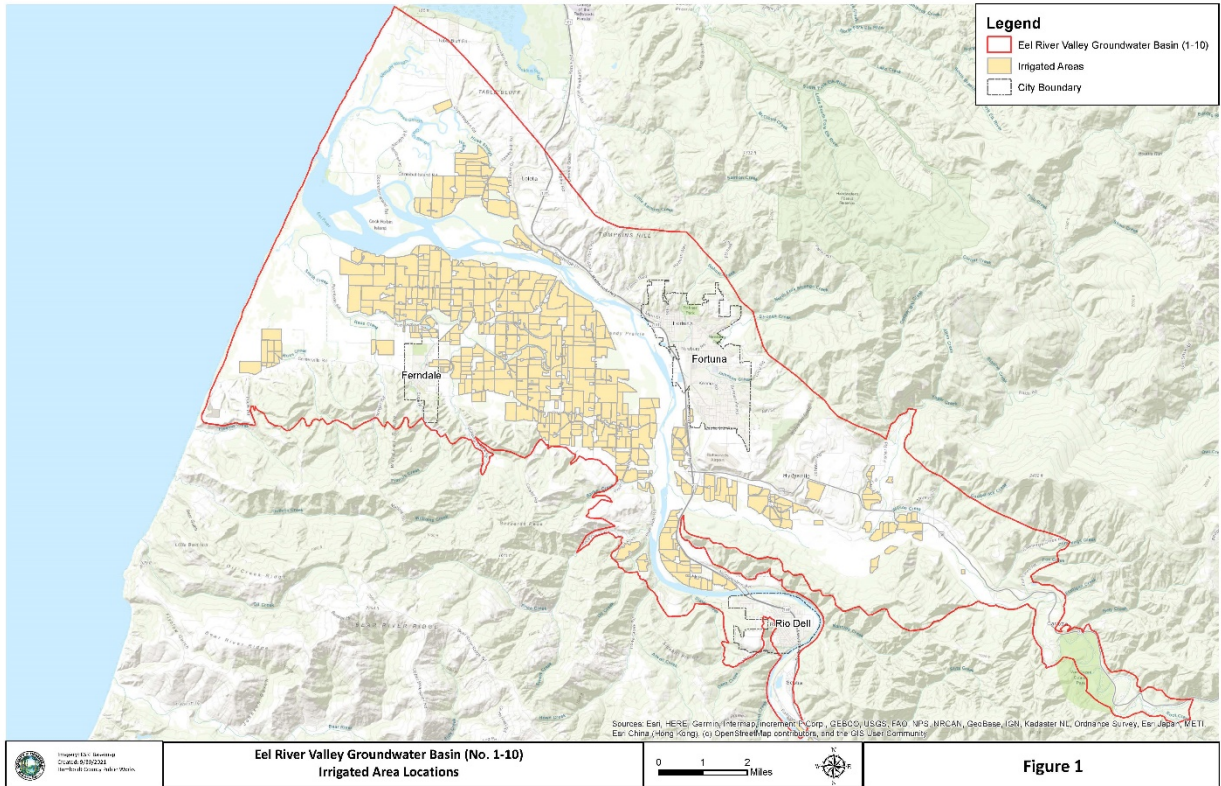
# 2. Inventory of Irrigated Land Areas and Irrigation Methods

## Irrigated Land Areas

The Eel River Valley is the center of Humboldt County’s dairy and beef cattle economy. Dairy producers and ranchers pump groundwater for pasture irrigation and ancillary activities such as dairy nutrient management and livestock watering. In 2021, the Humboldt County Resource Conservation District (HCRCD) updated the inventory of irrigated land areas within the basin, following their initial inventory in 2016. The results from this analysis are incorporated into the Land Use Technical Memorandum (GHD, 2021) and summarized in Table 1 and depicted on Figure 1.

**Table 1. Irrigated Land Use by Water Source in the ERVB (2021).**

<b>Irrigation Water Source</b>	<b>Acres</b>	<b>% of Total Acres</b>
Groundwater	12,952	96.4%
Surface Water	126	0.9%
Reclaimed Wastewater	352	2.6%
<b>Total:</b>	<b>13,430</b>	<b>100%</b>



**Figure 1. Irrigated Acreage Locations within the ERVB, updated 2021.**

**Irrigation Methods**

In 2021, a total of 12,952 acres of agricultural land were irrigated by groundwater using five types of irrigation equipment (Table 2).

**Table 2. Equipment Types Used for Irrigation with Groundwater in the ERVB (2021).**

<b>Irrigation Equipment Type</b>	<b>Acres</b>	<b>% of Total Acres</b>
Handline	6,779	53%
Traveling Gun	4,025	31%
Wheel Line	1,147	9%
K-Line	713	6%
Center Pivot	272	2%
Other	16	0.1%
<b>Total</b>	<b>12,952</b>	

**Handlines** distribute water through sprinkler pipes (aluminium pipe with a sprinkler on one end) connected in a lateral line extending off of a mainline supply. Handlines are moved by disconnecting, moving, and reconnecting each sprinkler pipe by hand to the lateral line's next location. Sprinkler pipes are typically 30 or 40 feet long and each setting lateral lines are typically moved 60 feet. The amount of water applied depends on the distance between sprinklers (length of pipe), nozzle size, pressure, distance between lateral line settings, and duration of each set.

**Traveling Guns** distribute water through a single large sprinkler that traverses a portion of the field each time the traveling gun is set. For each setting the traveling gun is moved to a new location and the large sprinkler pulled from the carriage and set to traverse a different portion of the field. The amount of water applied depends on the nozzle size, pressure, and speed the large sprinkler travels.

**Wheel Lines** distribute water through sprinkler pipes mounted on large wheels connected in a lateral line off of a mainline supply. Wheel lines are repositioned by operating a motorized mover in the center of the line with the sprinkler pipes serving as an axle. Sprinklers are typically spaced at 40-foot intervals along the wheel line and moved 60 feet each setting. The amount of water applied depends on the nozzle size, water pressure, and duration of each set.

**K-Lines** distribute water through a system of plastic lines with sprinkler pods spaced 40 to 50 feet along the lines. K-Lines are moved to a new location by dragging the plastic line with an ATV while the system is operating. K-Line systems are designed to maximize infiltration with the amount of water applied depending on sprinkler spacing, sprinkler size, and duration of each set.

**Center Pivots** distribute water through sprinklers positioned along an overhead pipe that rotates around a pivot point. The system is designed to apply water at an equal rate along the length of the pipe and the amount of water applied depends on the speed the center pivot rotates and nozzle size.

**Other** irrigations systems are used in less than 0.1% of the basin and include hoses, flood irrigation, or drip irrigation methods. These methods are used on small scale farms of 5 acre or less.

### 3. Water Year Type and Irrigation Season

#### Water Year Type Designations

A common practice in hydrology is to calculate total precipitation over a twelve-month period by designating a “water year” as the period extending from October 1 through September 30. For example, Water year 2021 extended from October 1, 2020, through September 30, 2021. Water year 2022 began on October 1, 2021. For watersheds where the majority of precipitation falls in the winter, the water year generally encompasses the entire wet season. Annual water budgets, which quantify inflows, outflows, and change in storage for a groundwater basin, are developed based on the annual water year period.

DWR (January 2021) presented a methodology for designating water year types for watersheds outside the Sacramento and San Joaquin Valleys to support the development of GSPs. DWR’s methodology is based on selecting a 30-year period and dividing the record into five categories of water year type according to specified weighting percentages (Table 3). This methodology results in 50% of the years in the 30-year period classified as Wet or Above Normal and 50% of the years classified as Below Normal, Dry, or Critical.

**Table 3. Water Year Classifications (DWR, January 2021)**

<b>Classification</b>	<b>Weighted Percentage</b>
Wet	30%
Above Normal	20%
Below Normal	20%
Dry	15%
Critical	15%

DWR (January 2021) published a data set of water year classifications for various hydrologic units around California, including the lower Eel River (HUC 18010105). This hydrologic unit encompasses 1,510 square miles and extends upstream to the confluence with the Middle Fork of the Eel River at Dos Rios, Mendocino County. This hydrologic unit encompasses a wide range of climatic conditions including a combination of coastal and inland areas. DWR (January 2021) notes that Groundwater Sustainability Agencies have the option of developing their own water year types based on best available information. Soil moisture, the primary factor determining when irrigation starts in the ERVB, is presumed to have a stronger correlation with local rainfall conditions rather than regional composite data. Therefore, the representation of water year types for the ERVB can be improved by using local rainfall data, as described below.

Long-term rainfall records (October 1963 through September 2021) were obtained from Jerry Lema of the Ferndale Museum. A rain gauge has been operated at the Ferndale Museum (515

Shaw Avenue) since October 1994. The current rain gauge was manufactured by Productive Alternatives and was provided by the National Weather Service in the 1990s when the museum served as an official gauging site. From October 1970 through October 1994, daily rainfall measurements were collected by George Anderson at 1345 Main Street in Ferndale. Information regarding the location of the rain gauge from October 1963 through October 1970 was not readily available. A summary of the monthly rainfall totals at Ferndale from October 1963 through June 2021 is provided in Appendix 1.

DWR's methodology for designating water year type for a given year takes into account the annual precipitation during the previous year by applying weighting factors to calculate an index value using the following equation:

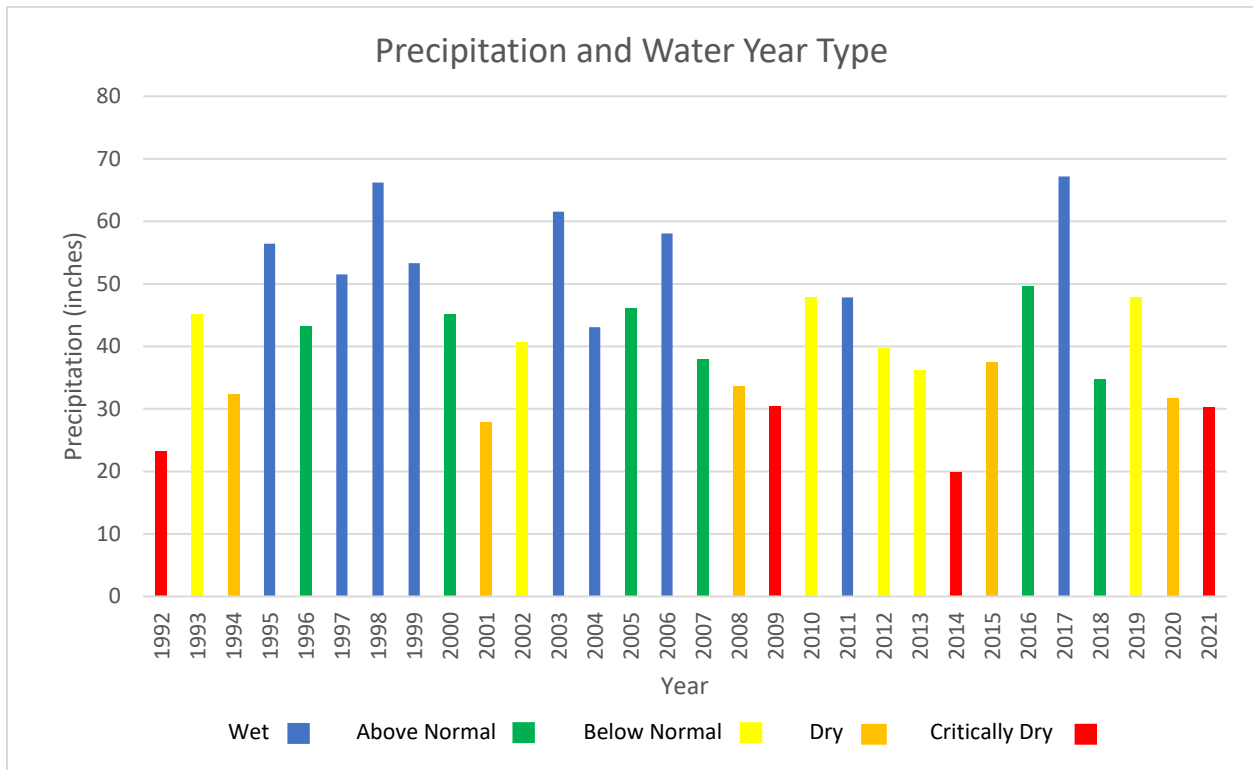
$$\text{Water Year Index} = (0.70 \times \text{current water year precipitation}) + (0.30 \times \text{previous water year precipitation})$$

The equation is applied to each year in the 30-year period to develop index values, which are then ranked from highest to lowest. The ranking position based on index values is used to allocate the years of the 30-year period into the designated distribution of five water year type categories. The results from applying this methodology to the Ferndale rainfall data for the 30-year period from 1992 through 2021 are summarized on Table 4 and depicted on Figure 2. Based on this analysis, water year 2021 is considered a critical water year.

**Table 4. Water Year Types with Annual Precipitation, Index Values and Ranking (1992-2021).**

Water Year	Annual Precipitation (inches)	Water Year Index	Index Rank (30 = highest #, 1 =lowest #)	Water Year Type
2017	67.2	61.9	30	Wet
1998	66.2	61.8	29	Wet
1999	53.3	57.2	28	Wet
2003	61.6	55.3	27	Wet
2006	58.0	54.5	26	Wet
1995	56.4	49.2	25	Wet
1997	51.5	49.0	24	Wet
2004	43.1	48.6	23	Wet
2011	47.8	47.8	22	Wet
2000	45.1	47.6	21	Above Normal
1996	43.3	47.2	20	Above Normal
2016	49.6	46.0	19	Above Normal
2005	46.1	45.2	18	Above Normal
2018	34.8	44.5	17	Above Normal
2007	38.0	44.0	16	Above Normal
2019	47.9	43.9	15	Below Normal
2010	47.9	42.7	14	Below Normal
2012	39.7	42.1	13	Below Normal
1993	45.1	38.6	12	Below Normal
2013	36.2	37.3	11	Below Normal
2002	40.7	36.9	10	Below Normal
2020	31.7	36.5	9	Dry
1994	32.4	36.2	8	Dry
2008	33.7	35.0	7	Dry
2001	28.0	33.1	6	Dry
2015	37.5	32.2	5	Dry
2009	30.5	31.5	4	Critical
2021	30.3	30.7	3	Critical
2014	19.9	24.8	2	Critical
1992	23.3	23.7	1	Critical

**Figure 2. Water Year Types (1992-2021), Based on Rainfall Data Collected in Ferndale**



**Irrigation Season Durations**

Agricultural producers begin irrigating when applied water is needed to supplement soil moisture in order to maintain the growth of pasture grasses or crops. The start-date for irrigation in the spring varies considerably within the ERVB and year to year. Factors that affect the start-date for irrigation include the amount of precipitation in late winter and early spring (especially March and April), wind and air temperature, soil type, labor availability, and overall land management approach. In general, irrigation typically starts earlier in the inland portion of the basin and later in the central and coastal portions of the basin. The end-date for irrigation in the fall is generally on or around October 1, when plant growth slows considerably as day length (photoperiod) shortens and air and soil temperatures drop. For the purpose of this memorandum, start-dates for irrigation were estimated for each of the five water year types based on interviews with producers and professional judgement (Table 5). These estimates identify the date when some producers begin irrigation. Other producers will not start irrigating for several weeks. As a conservative assumption to avoid underestimating groundwater use, this memorandum assumes that all irrigation in the ERVB begins on the start date for that water year type.

**Table 5. Water Year Types for the ERVB and Irrigation Season Estimates (1992-2021).**

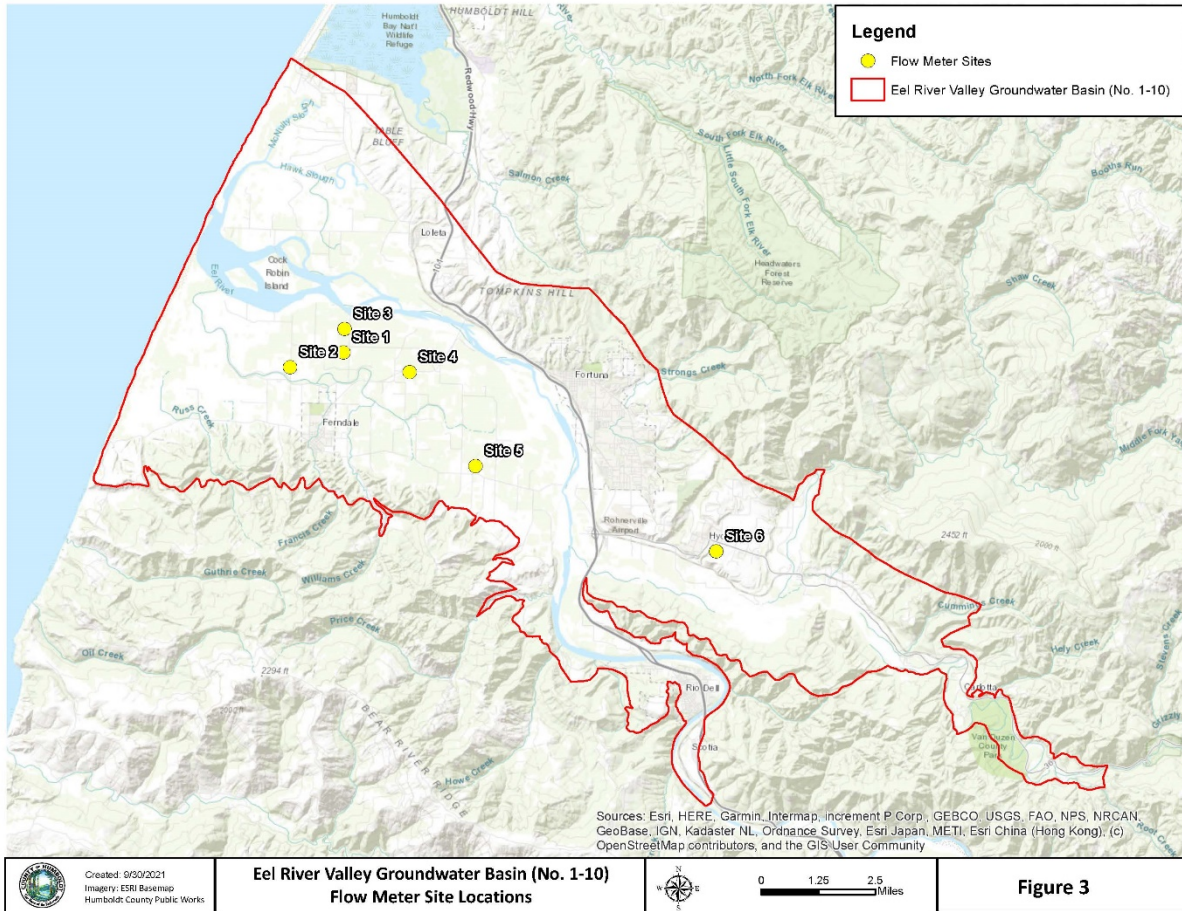
<b>Water Year Type</b>	<b>Estimated Irrigation Season</b>	<b>Days in Irrigation Season</b>	<b>Years Corresponding to Water Year Type</b>
Wet	June 1 – October 1	121	1995, 1997, 1998, 1999, 2003, 2004, 2006, 2011, 2017
Above Normal	May 20 – October 1	133	1996, 2000, 2005, 2007, 2016, 2018
Below Normal	May 15 – October 1	138	1993, 2002, 2010, 2012, 2013, 2019
Dry	April 30 – October 1	153	1994, 2001, 2008, 2015, 2020
Critical	April 15 – October 1	168	1992, 2009, 2014, 2021

## 4. Irrigation Water Use Estimate

Previous studies provided indirect estimates of groundwater use for agricultural irrigation in the ERVB using a variety of methods (discussed in Section 7). Here, irrigation water use is estimated based on direct measurements using monitoring data collected during the 2021 water year from eight flow meters. Flow meter data are used to calculate total groundwater volume extracted at each meter location and this information is then used to extrapolate across the ERVB to provide an estimate of total groundwater volume extracted for agricultural irrigation by water year type.

### 4.1. Flow Meter Data Collection

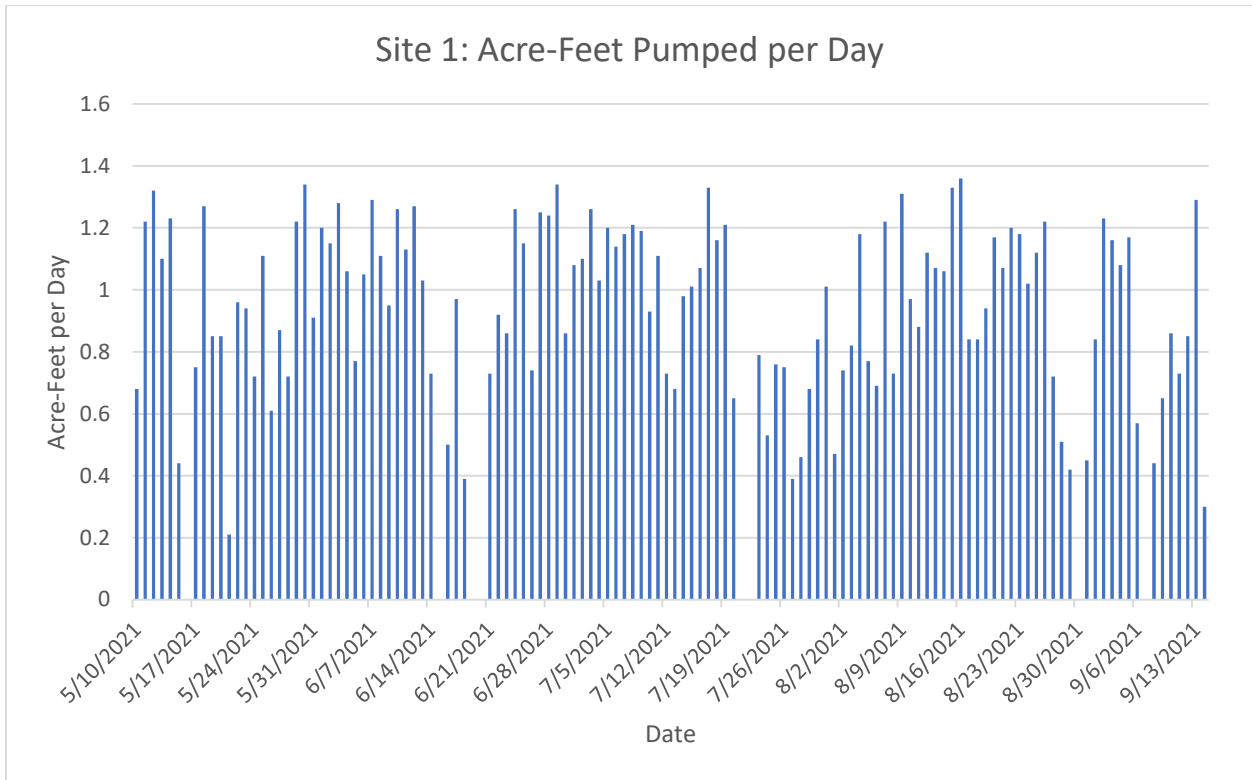
Flow meters were purchased and installed by the Humboldt County Groundwater Sustainability Agency in 2021 prior to the initiation of irrigation on six private wells to measure water use rates (Sites 1-6 on Figure 4). The general goal was to select sites that are spatially distributed across the basin and represent the range of irrigation system types. In addition, two producers volunteered to provide data from their existing flow meters (Sites 7 and 8). Collectively, the eight sites include three traveling guns, two center pivots, one wheel line, one handline, and one K-line. At all sites, the flow meters began measuring total cumulative water volume at the start of irrigation. At five sites, the flow meters did not begin measuring daily pumping rates until after irrigation had begun. At site 3, the daily pumping rate data were affected by a software problem and are considered questionable. Readings of total cumulative water volume were used as the basis for water use calculations as described in Section 4.2.



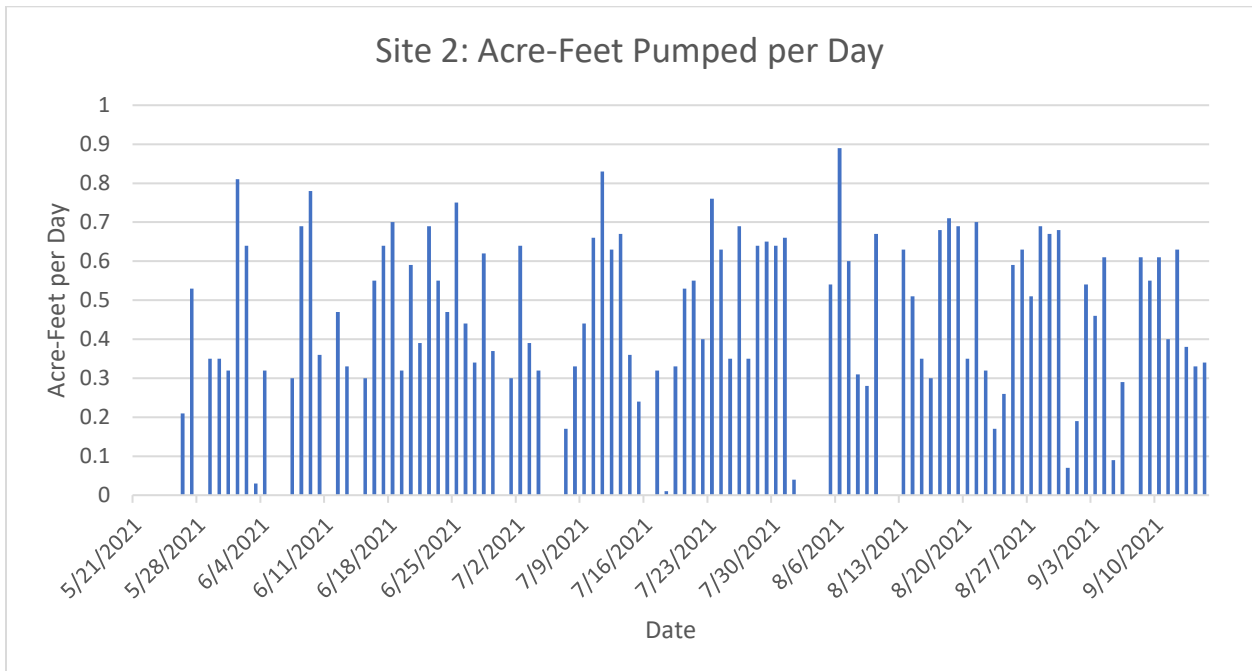
**Figure 3. Locations of Six Installed Flow Meters for Irrigation Water Use Calculations.**

Sites 1-7 are equipped with Seametrics AG3000 Series Flanged Magmeters. The AG3000 Series is a spool-type electromagnetic flowmeter for use in irrigation applications in two-inch to 12-inch diameter pipe. The flow meter has no moving parts, provides unobstructed flow, and is resistant to wear from debris found in ground or surface water (Seametrics 2021). Data from Sites 1-7 were downloaded directly from the flow meters by HCRCD staff using Flowinspector Version 2.5.0. Flow meters record the date, time, gallons per minute, and total gallons or acre-feet every minute or every hour. Data were downloaded as recorded (minute or hour intervals) every 21 to 30 days beginning in May 2021. Site 8 is equipped with a Lindsay Growsmart IM 3000 magnetic flow meter which records the date and total gallons per hour. Data from Site 8 were downloaded via online access every 21-30 days beginning in April 2021.

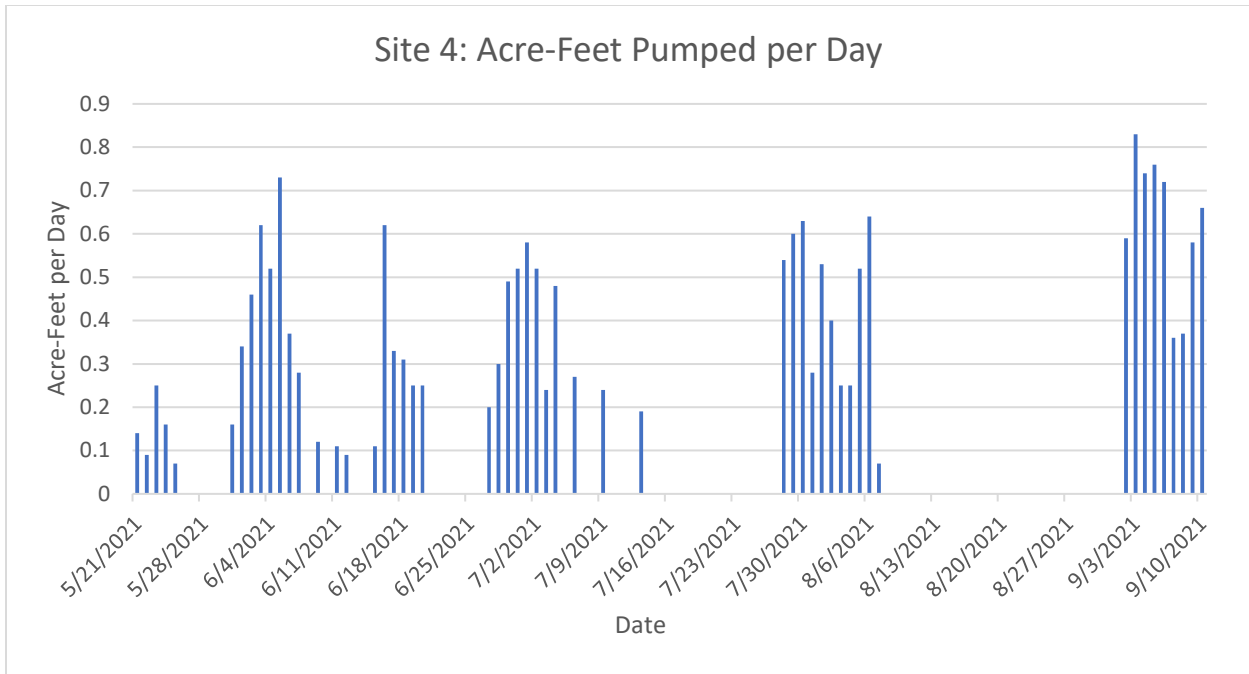
**Figures 4-10** show daily pumping rates (acre-feet per day) where that data is available for each site except Site 3. Figures 4-10 indicate that groundwater is not pumped continuously through the entire irrigation season. Breaks in irrigation occur to allow for harvesting, moving equipment, and other activities.



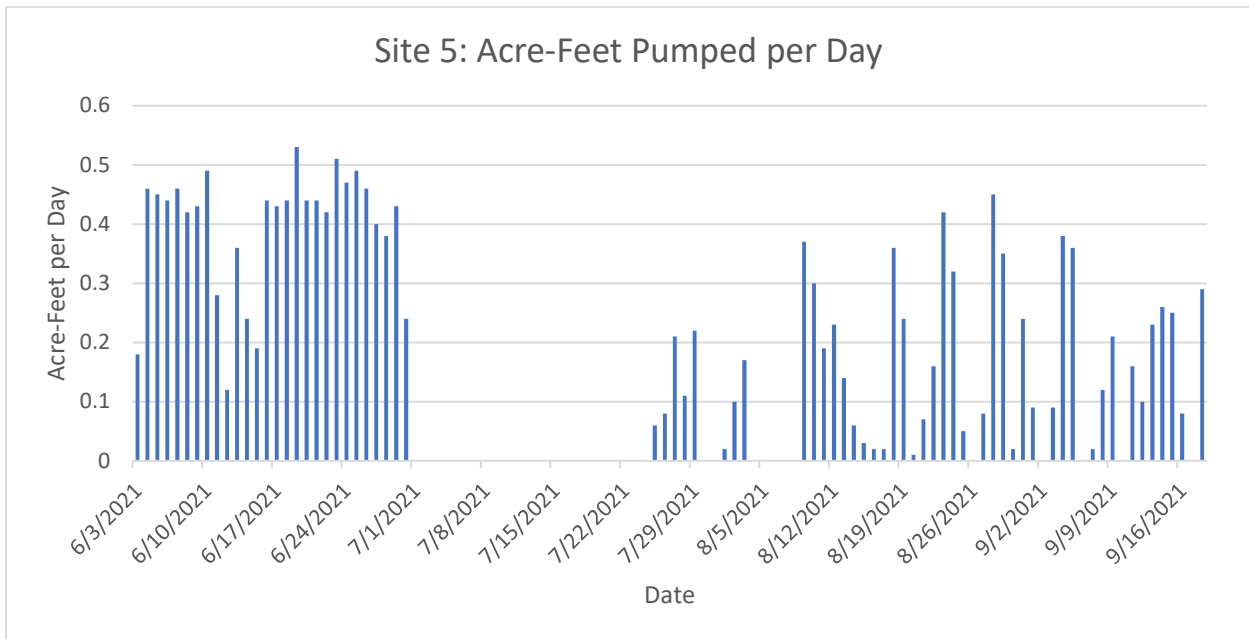
**Figure 4. Site 1 Daily Groundwater Pumping Rates (Acre-feet per day).**



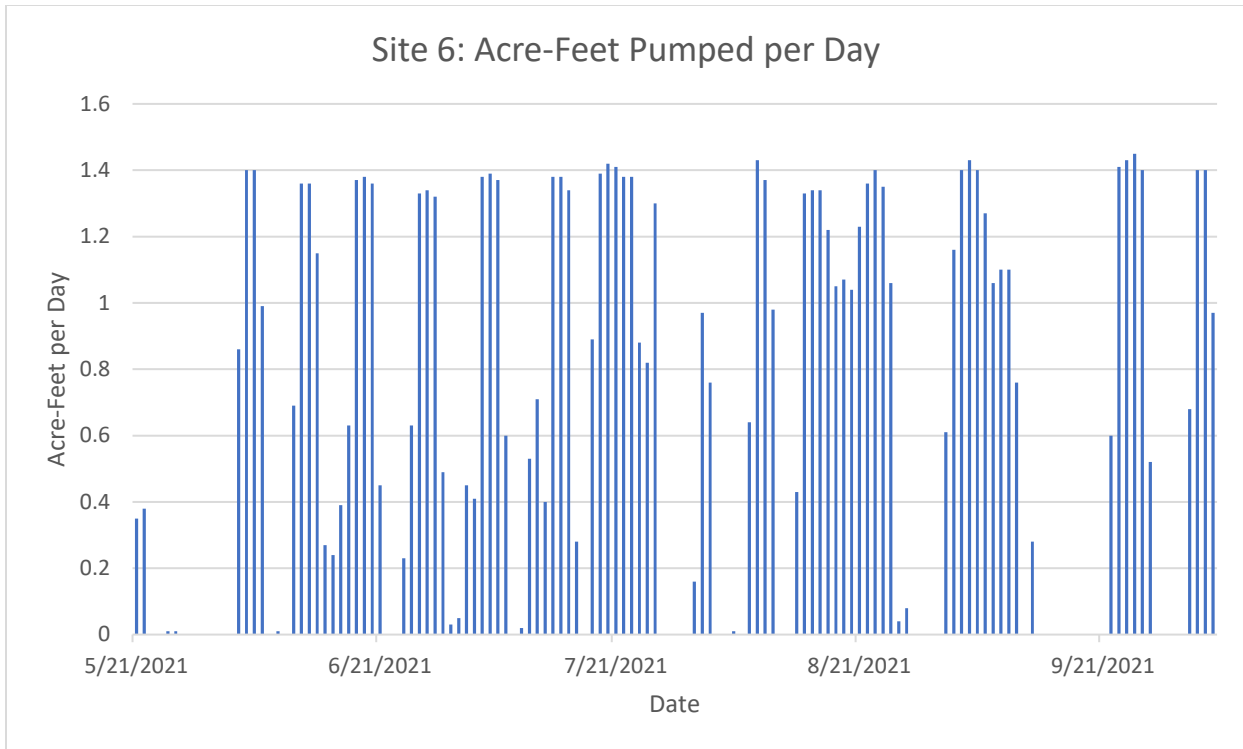
**Figure 5. Site 2 Daily Groundwater Pumping Rates (Acre-feet per day).**



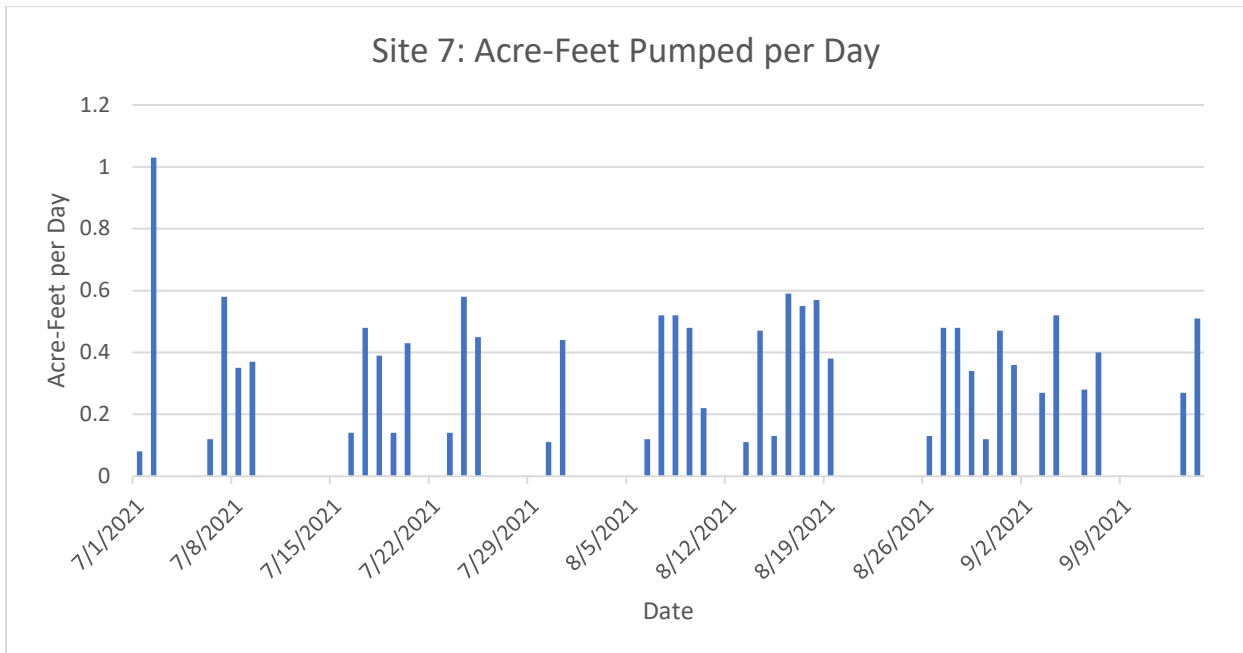
**Figure 6. Site 4 Daily Groundwater Pumping Rates (Acre-feet per day).**



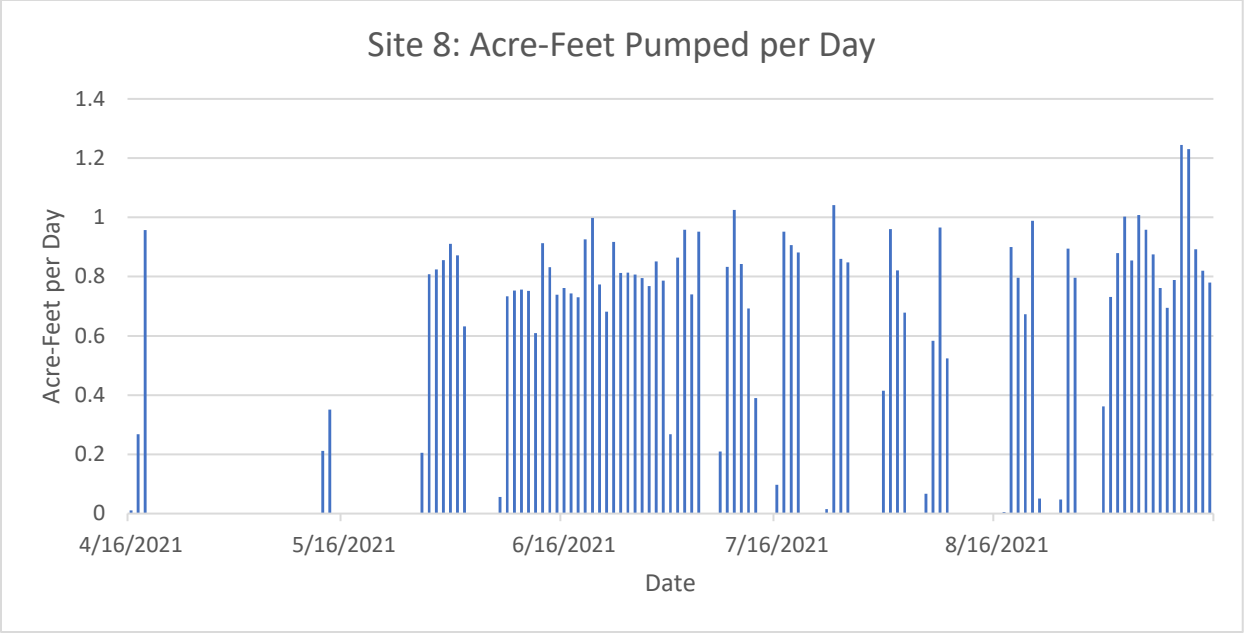
**Figure 7. Site 5 Daily Groundwater Pumping Rates (Acre-feet per day).**



**Figure 8. Site 6 Daily Groundwater Pumping Rates (Acre-feet per day).**



**Figure 9. Site 7 Daily Groundwater Pumping Rates (Acre-feet per day).**



**Figure 10. Daily Groundwater Pumping Rates (Acre-feet per day).**

## 4.2. Calculations

Table 6 provides a summary of flow meter data collected during the 2021 water year.

**Table 6. Summary of 2021 Flow Meter Data.**

Site:	1	2	3	4	5	6	7	8
Irrigation System	Traveling Gun	Traveling Gun	K-Line	Wheel Line	Handline	Center Pivot	Traveling Gun	Center Pivot
Acres	60	96	124	22	47	83	49	55
Date Flow Meter Installed	4/5/2021	4/19/2021	4/12/2021	4/19/2021	5/18/2021	4/19/2021	2017	2017
Irrigation Period	5/10/2021-9/14/2021	5/9/2021-9/15/2021	4/29/2021-10/5/2021	5/18/2021-9/10/2021	6/3/2021-9/18/2021	5/3/2021-10/5/2021	4/29/2021-9/14/2021	4/16/2021-9/15/2021
Date Range for collection of daily use rates	5/21/2021-10/11/2021	5/21/2021-10/11/2021	N/A (Note 1)	5/21/2021-10/11/2021	5/21/2021-10/11/2021	5/21/2021-10/11/2021	7/1/2021-10/11/2021	4/16/2021-10/11/2021
Duration of irrigation period (days)	127	129	159	115	107	155	138	152
Total groundwater pumped during water year (Acre-feet)	114.47	51.22	182.14	21.19	19.25	101.29	28.41	62.64

Note 1: The flow meter at Site 3 did not collect accurate daily flow measurements due to a programming problem. However, the total water use value measured by the totalizer was accurate.

Table 6 indicates that the start-date for irrigation in 2021 varied over a range of approximately seven weeks (from April 16 to June 3) and the end-date ranged over three and a half weeks (from September 10 to October 5). Although water year 2021 was classified as “critical,” the assumed start-date of April 15 does not correspond well with the actual start-dates for the eight irrigation systems with flow meters. However, the estimated irrigation start-dates indicated on Table 5 are used in the calculations for total annual groundwater use based on the assumption that these start-dates are representative over a 30-year period.

Total annual groundwater use for each site as a function of water year type was estimated by extrapolating the monitoring data from the 2021 water year using the following equation:

Total Groundwater Pumping (Acre-feet per Acre per year) =

$$\frac{\text{Total Groundwater Extracted during WY 2021 (Acre-Feet)}}{\text{Irrigated Land (Acres)}} \times \frac{\text{\# Days in Irrigation Season based on Water Year Type}}{\text{\# Days Pumping Occurred in WY 2021}}$$

Estimates of total annual groundwater use based on the five water year types for each of the eight monitoring sites are provided in Table 7.

**Table 7. Extrapolated Total Annual Groundwater Use for Monitoring Sites (Acre-feet per Acre per year).**

Site:	1	2	3	4	5	6	7	8
Irrigation System	Traveling Gun	Traveling Gun	K-Line	Wheel Line	Handline	Center Pivot	Traveling Gun	Center Pivot
Wet	1.8	0.5	1.1	1.0	0.5	1.0	0.5	0.9
Above Normal	2.0	0.6	1.2	1.1	0.5	1.0	0.6	1.0
Below Normal	2.1	0.6	1.3	1.2	0.5	1.1	0.6	1.0
Dry	2.3	0.6	1.4	1.3	0.6	1.2	0.6	1.1
Critical	2.5	0.7	1.6	1.4	0.6	1.3	0.7	1.3

As shown on Table 7, two of the traveling gun sites (sites 2 and 7) had nearly identical results, while one travel gun site (site 1) had a considerably higher rate. Site 1 fields were generally irrigated for longer periods than Sites 2 and 7. The producer at this site had less concerns about electricity costs and did not have limitations on labor in 2021. The two center pivot sites (sites 6 and 8) had similar results.

The distribution of irrigation system types measured at the eight monitoring sites does not exactly match the distribution of irrigation system types throughout the basin (Table 2). For example, handlines account for over half the irrigation systems in the basin; however, only one of the eight monitored sites was a handline. In order to provide the most representative estimate of groundwater pumping throughout the entire basin, the monitoring results from the eight monitoring sites were grouped and averaged, as follows:

- Results from the three travel gun sites were averaged (Sites 1, 2, 7).
- Results from the two center pivot sites were averaged (Sites 6, 8).
- Results from the handline and wheel-line sites were averaged because these equipment types are very similar (Sites 4, 5).
- Results from the k-line system were assumed to represent all k-line systems (Site 3).

Total annual groundwater use as a function of water year type was estimated by multiplying the water use rate for each equipment grouping by the total acres irrigated with that equipment, from Table 2. The results from these calculations are provided in Table 8.

**Table 8. Extrapolated Total Annual Groundwater Use for the Entire Basin.**

	Traveling Gun		K-Line		Handline and Wheel-line		Center Pivot		Total Basin	
	Acre-ft/Acre	Total Acre-ft	Acre-ft/Acre	Total Acre-ft	Acre-ft/Acre	Total Acre-ft	Acre-ft/Acre	Total Acre-ft	Total Acre-ft	Acre-ft/Acre
Wet	0.9	3,792	1.1	797	0.7	5,852	0.9	253	10,694	0.8
Above Normal	1.0	4,168	1.2	876	0.8	6,432	1.0	278	11,754	0.9
Below Normal	1.1	4,325	1.3	909	0.8	6,674	1.1	288	12,196	0.9
Dry	1.2	4,795	1.4	1,008	0.9	7,399	1.2	320	13,522	1.0
Critical	1.3	5,265	1.6	1,107	1.0	8,125	1.3	351	14,848	1.2

The total volume of groundwater pumped in the basin ranges from 10,694 acre-feet in a wet year to 14,484 acre-feet in a critical year. The water use rate ranges from 0.8 acre-feet of water per irrigated acre per year in a wet year to 1.2 acre-feet of water per irrigated acre per year in a critical year.

## 5. Uncertainty

This section discusses the uncertainty associated with the assumptions and data inputs utilized for the estimate of irrigation groundwater use in this memorandum.

- Irrigated acres. The accuracy of this number is considered high. The estimate was developed as an update to a previous inventory of irrigated land in the basin (HCRCD, 2016) so there was strong baseline information. The estimate for this study was based on a parcel-by-parcel review with information collected through interviews with landowners and site visits for field verification. Areas were calculated using Geographic Information System (GIS) software.
- Flow meter data quality. The quality of the flow meter data is considered high. Flow meters are established, conventional technology. The meters were installed by Northcoast Pumphouse according to the manufacturer's specifications. Calculations were based on the totalizer measurements which provide a running total of water volume passing through the meter. Totalizer readings were collected manually for seven of the eight sites and through an on-line interface for one of the sites. One of the sites (Site 3) had software problems that impacted the daily use rate data but the totalizer reading was not affected.
- Representativeness of monitoring sites. Water use varies across the basin based on location, soils, management approach, and other factors. Water use was directly measured at eight sites which irrigated a total of 536 acres, or 4% of the irrigated land in the basin. Each of the five irrigation system types was represented in the monitoring sites. However, only one site utilized a handline system which accounts for 53% of the irrigation in the basin. To avoid reliance on a single data point for this large portion of the basin, the results for handline and wheel line were averaged because these systems are very similar. The results from the three monitoring sites with traveling gun systems were averaged, as were the two results from the two sites with center pivot systems. Averaging of multiple measurements helps reduce the potential for an outlier to skew the results.
- Duration of irrigation season. The duration of the irrigation season varies considerably year to year and from producer to producer. For this memorandum, a method was developed to estimate the duration of irrigation season based on water year type. This approach assumes that there is a significant correlation between irrigation start-date and water year type. However, this correlation has not been verified. The presumed end-date of October 1 also has some uncertainty based on soil moisture and temperature, although the end-date is expected to vary less than the start-date. This approach was conservative for the 2021 water year because irrigation at the eight monitoring sites started an average of three weeks after the estimated start-date of April 15 for a critical water year and an average of 12 days before the estimated end-date of October 1. Alternative approaches for estimating the duration of the irrigation season could be investigated in the future to improve the correlation between meteorological data and local irrigation practices.

## 6. Dairy Nutrient Management

The ERVB includes approximately 40 dairies which have considerable variability in terms of dairy operations and nutrient management system designs. In addition to using groundwater for irrigating pastures, dairies use groundwater as a source of water for cleaning facilities and supplying the cooling system in milk coolers. This water is typically supplied by a different well than the irrigation well. All dairies use water to clean the milking floor, and a few dairies use water to clean other areas of the facility. These activities generate dairy process water which is collected, along with precipitation runoff and manure, into earthen ponds, lagoons, or cement pits (collectively called “ponds”). Liquids in the ponds are periodically applied to surrounding pastures and cropland to replenish soil nutrients in accordance with a Nutrient Management Plan. At some dairies, irrigation water is added to flush the manure lines and condition the pond water for distribution. Approximately every 10 to 30 days (year-round), nutrients from ponds are applied as a liquid or slurry to pastures and cropland with a traveling gun or manure truck.

A typical rule of thumb is that each dairy uses approximately 500 to 1,000 gallons per day for milk cooling and wash-down water for the milking floor. A conservative estimate of 1,000 gallons per day yields an annual use of 1.1 acre-feet. The majority of dairies use equipment to scrape holding pens without using wash-down water, while a small percentage (approximately 10%) use water to flush the holding pens. Pen flushing uses approximately 12,000 gallons per day one-third of the year (120 days), yielding a total of 5.5 acre-feet per year. Some dairies with pen flushing have systems that recycle the wash water, so the amount of pumped water is less than the estimate of daily use.

Assuming 36 dairies use equipment to scrape the holding pens (no wash water) and four dairies use groundwater for pen flushing, the total water use for facility operations and nutrient management at all dairies in the ERVB would be:

$$(36 \times 1.1 \text{ acre-feet}) + (4 \times 5.5 \text{ acre-feet}) = 62 \text{ acre-feet per year}$$

This conservative estimate is 0.4% of the total volume of irrigation water used in a wet year and 0.6% of the total volume used for irrigation in a critical year.

## 7. Review of Published Groundwater Use Values

Previous estimates of irrigation water use in the ERVB are summarized on Table 9 and discussed below.

**Table 9. Comparison of Previously Estimated Irrigated Acreages and Water Use Studies**

Source	Irrigated Land (Acres)	Irrigation Water Use Volume (Acre-Feet per year)	Water Use Rate per Acre (Acre-Feet per Acre per year)
DWR (1978) [from USGS (1968)]	11,700	18,800	1.0 to 1.7
USGS (1978)	Not reported	17,300	1.0
DWR (2003)	Not reported	49,000	Not reported
DWR (2014)	33,309	Not reported	Not reported
HCRCDC (2016)	13,558	10,265 to 16,680	0.8 to 1.2
DWR (2019)	13,446	40,848	3.0
Humboldt County/HCRCDC/WRS (2021)	12,952	10,694 to 14,848	0.8 to 1.2

### USGS (1978)

The U.S. Geological Survey published “Ground-Water Conditions in the Eureka Area, Humboldt County, California, 1975” (Water-Resources Investigations 78-127) in December 1978. The estimated groundwater use in the Eel River floodplain and the Eel River and Van Duzen River valleys for 1975 was 17,300 acre-feet (Table 3 in USGS, 1978). This estimate is based on electrical-energy use and pump-efficiency test information provided by the utility company PG&E. The 1978 USGS report also presents data compiled by DWR from 1968 which indicated an estimated total of 18,800 acre-feet of water was applied over 11,700 acres within the same study area. The 1968 DWR data were based on the “land-use” method which utilized a unit applied-water factor ranging from 1.0 to 1.7 acre-feet per acre based on crop type. USGS (1978) concluded that groundwater pumping had remained fairly stable from the late 1950s to the mid-1970s.

### DWR (2003)

DWR updated “California’s Groundwater” (Bulletin 118) in 2003. The description for the Eel River Valley Groundwater Basin includes an estimate of 49,000 acre-feet of water use for agricultural purposes. The document does not provide an estimate of irrigated acreage or water use rate (acre-feet per acre) within the basin. The document references a survey conducted by

DWR in 1996; however, additional information regarding the survey data or methodology is not provided.

#### DWR (2014)

In June 2014, DWR published a spreadsheet for the California CASGEM and Groundwater Sustainability Basin Prioritization. This spreadsheet reported 33,309 acres of irrigated land in the ERVB. An estimate of groundwater use for agriculture was not provided but the spreadsheet listed total groundwater use in the basin as 55,000 acre-feet. These estimates for irrigated land and total groundwater use are significantly higher than other estimates for the basin. Discussion regarding the methodology and supporting information for the estimates in DWR (2014) have not been published.

#### HCRC (2016)

In December 2016, the HCRC published a technical memorandum documenting an estimate of irrigation groundwater use to support the preparation of a Groundwater Sustainability Plan Alternative for ERVB. The 2016 study utilized estimates of pumping capacity for different irrigation systems based on pump size and rating curves through consultation with equipment suppliers and agricultural producers. The estimates of pumping capacity were extrapolated across the basin based on an estimate of irrigate acreage and estimates of the irrigation season duration as a function of three water year types (dry, normal, wet). Total water use in the basin ranged from 10,265 acre-feet in a wet year (0.8 acre-feet per acre per year) to 16,680 acre-feet in a dry year (1.2 acre-feet per acre per year).

#### DWR (2019)

In January 2019, DWR released updated prioritization levels for a majority of the groundwater basins in California including ERVB. The spreadsheet accompanying these results reported 13,446 acres of irrigated land and 40,848 acre-feet of agricultural groundwater use. DWR issued a paper entitled Sustainable Groundwater Management Act 2018 Basin Prioritization – Process and Results, which discussed the components of the point system that was used by DWR to set basin priority levels. Agricultural groundwater use was estimated using the Cal-SIMETAW model (California Simulation of Evapotranspiration of Applied Water), which calculates water use demand by crop type based on soil information, growth dates, crop coefficients, and evapotranspiration data. Cal-SIMETAW calculates theoretical water demand for optimizing plant growth and applies an efficiency percentage for losses during the application process to calculate total pumped water. DWR applied the model based on hydrological conditions and land use information for the 2014 water year.

The results for agricultural groundwater use in DWR (2019) are approximately three times higher than the results in HCRC (2016) and the results in this current Technical Memorandum.

This deviation raises questions about the applicability of Cal-SIMETAW for estimating groundwater use in ERVB. The source of the climatological data for the Cal-SIMETAW modelling in DWR (2019) is not well documented, but it was not local data because the first California Irrigation Management Information System (CIMIS) in the basin became operational in August 2019. ERVB has unique climatological conditions due to the close proximity to the Pacific

Ocean, with relatively low air temperatures, high relative humidity, and regular occurrences of fog and dew during the irrigation season. In addition, an important physical property is the relatively high water table in the alluvial floodplain portions of the basin. Groundwater in these areas can be found within five to ten feet below ground surface during much of the year. Therefore, a significant portion of the water demand from plants may be supplied by soil moisture and the capillary fringe above the water table, which reduces the need for applied water. Humboldt County is having ongoing discussions with DWR regarding the appropriateness of using Cal-SIMETAW for groundwater-related evaluations in the ERVB.

## 8. Summary

This study determined that the total volume of groundwater pumped for agricultural irrigation in the basin ranges from 10,694 acre-feet in a wet year to 14,848 acre-feet in a critical year. The water use rate ranges from 0.8 acre-feet of water per irrigated acre per year in a wet year to 1.2 acre-feet of water per irrigated acre per year in a critical year. This study is the first effort to rely on direct measurements and represents the best available information for estimating groundwater use for agricultural irrigation in the ERVB. Groundwater use for dairy nutrient management is less than 1% of the water used for irrigation.

The results from this study are consistent with the results in HCRCO (2016) and the older studies of USGS (1978) and DWR (1968) but vary from the results of DWR (2003) and DWR (2019). The basis for the results in DWR (2003) have not been published. DWR (2019) is based on computer modelling using Cal-SIMETAW, which may not be appropriate for estimating groundwater use in the ERVB due to the unique climatological and groundwater conditions in the basin.

## 9. References

California Department of Water Resources. January 2021. Sustainable Groundwater Management Act Water Year Type Dataset Development Report.

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Humboldt County Resource Conservation District. December 2016. *Technical Memorandum – Irrigation Water Use Study*.

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## APPENDIX 1

Ferndale Monthly Rainfall Totals (October 1963-September 2021)

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Annual
1964	4.20	7.12	3.44	10.72	1.18	5.25	0.43	1.42	0.54	0.23	0.22	0.07	34.82
1965	2.59	11.50	18.55	7.26	1.61	1.06	6.01	0.29	0.51	0.07	0.35	0.06	49.86
1966	0.74	7.01	6.58	9.88	3.85	6.37	1.39	0.03	0.36	0.22	0.44	1.25	38.12
1967	0.71	9.87	7.48	8.49	0.97	8.51	4.73	1.16	0.58	0.02	0.06	1.84	44.42
1968	2.29	4.77	4.66	9.32	2.98	4.10	0.62	0.81	0.17	0.22	2.11	0.35	32.40
1969	2.56	5.81	11.55	13.88	11.1	1.45	3.57	1.10	0.53	0.16	0.01	0.38	52.10
1970	1.85	3.96	9.72	12.4	3.77	2.88	1.62	0.80	0.21	0.00	0.00	0.00	37.21
1971	1.57	10.91	10.75	6.32	3.49	7.93	2.73	0.77	1.25	0.13	0.45	1.03	47.33
1972	1.36	7.20	8.21	6.61	6.89	4.30	3.29	0.71	0.47	0.02	0.07	0.48	39.61
1973	4.77	5.23	7.12	8.13	4.48	7.25	0.77	0.00	0.49	0.01	0.11	1.88	40.24
1974	3.45	19.67	7.89	9.66	6.78	8.24	4.08	0.38	0.49	0.35	0.37	0.00	61.36
1975	1.18	2.14	8.71	5.45	9.30	11.92	3.07	0.56	0.29	0.15	0.31	0.00	43.08
1976	6.91	5.51	5.95	2.19	7.66	3.00	3.50	0.28	0.16	0.00	0.17	3.37	38.70
1977	2.14	5.32	7.38	10.35	8.59	3.88	4.80	0.94	0.19	0.14	1.58	0.06	45.37
1978	0.16	3.65	0.62	1.93	3.20	4.72	1.13	2.44	0.32	0.06	0.41	2.71	21.35
1979	0.04	0.99	2.80	4.63	6.97	3.31	3.20	1.81	0.03	0.28	0.67	0.55	25.28
1980	7.66	5.86	4.19	3.51	7.21	5.58	4.45	1.27	0.14	0.01	0.08	0.25	40.21
1981	1.05	2.07	6.83	11.55	4.40	5.32	0.72	1.46	0.24	0.05	0.06	0.93	34.68
1982	3.57	10.91	7.57	5.47	4.68	8.42	7.61	0.06	0.56	0.18	0.14	0.48	49.65
1983	5.91	7.89	11.64	9.26	11.40	10.97	6.23	1.32	0.71	0.90	3.78	0.18	70.19
1984	1.04	12.69	14.46	0.66	4.97	4.35	2.77	1.60	1.00	0.02	0.05	0.13	43.74
1985	3.68	16.34	4.47	0.76	4.18	4.94	0.27	0.70	0.96	0.05	0.32	1.10	37.77
1986	3.97	3.42	2.66	8.50	11.65	6.31	1.58	1.88	0.14	0.02	0.02	2.92	43.07
1987	1.53	1.90	4.80	6.76	4.43	10.03	0.90	0.31	0.17	0.24	0.08	0.05	31.20
1988	0.75	3.87	12.55	6.78	0.18	1.21	2.14	1.89	2.68	0.09	0.03	0.05	32.22
1989	0.56	9.93	7.67	5.08	3.11	7.98	1.66	1.16	0.25	0.02	0.37	0.95	38.74
1990	3.25	2.01	0.71	7.46	5.77	3.18	1.45	3.65	0.23	0.43	0.51	0.12	28.77
1991	2.07	2.89	2.63	0.91	3.36	7.84	1.43	1.88	0.31	0.43	0.93	0.08	24.76

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Annual
1992	1.24	2.33	2.10	3.18	6.70	4.41	1.87	0.22	0.72	0.19	0.15	0.17	23.28
1993	1.98	2.57	10.44	8.20	6.20	4.36	4.60	3.70	1.71	0.49	0.64	0.27	45.16
1994	0.47	1.77	7.61	5.54	8.59	2.86	3.12	1.49	0.57	0.13	0.04	0.20	32.39
1995	0.50	7.21	7.69	16.22	2.17	12.52	6.72	1.38	1.11	0.26	0.19	0.46	56.43
1996	0.58	1.32	11.97	9.70	8.53	3.33	5.02	1.90	0.03	0.07	0.11	0.75	43.31
1997	2.43	5.19	23.13	9.71	2.50	2.65	2.76	0.44	1.13	0.07	0.63	0.85	51.49
1998	2.68	8.36	5.95	14.76	17.08	8.79	3.51	3.48	0.76	0.53	0.14	0.17	66.21
1999	2.26	11.80	6.05	4.95	12.13	10.43	3.00	1.40	0.30	0.17	0.65	0.15	53.29
2000	1.79	7.97	4.93	10.70	9.71	3.00	3.38	2.22	0.56	0.26	0.14	0.44	45.10
2001	3.13	3.41	2.29	5.18	5.61	2.96	3.04	0.46	0.77	0.33	0.54	0.24	27.96
2002	0.95	7.66	11.50	6.36	5.58	4.87	2.45	0.80	0.22	0.11	0.05	0.18	40.73
2003	0.26	3.93	26.71	4.98	3.63	6.55	12.98	1.45	0.09	0.06	0.47	0.45	61.56
2004	0.72	6.39	11.08	7.65	11.01	2.36	1.35	1.36	0.23	0.19	0.43	0.31	43.08
2005	6.29	2.34	8.79	7.25	3.07	6.88	4.86	3.27	3.03	0.10	0.14	0.08	46.10
2006	1.83	6.17	14.52	9.89	6.42	13.04	4.69	0.89	0.27	0.14	0.02	0.16	58.04
2007	0.54	7.36	7.78	1.96	12.04	3.01	2.66	1.23	0.29	0.84	0.05	0.23	37.99
2008	3.15	2.28	7.85	10.70	4.12	2.59	1.84	0.11	0.43	0.15	0.44	0.06	33.72
2009	1.25	3.87	6.37	1.43	7.91	5.44	1.11	1.99	0.24	0.21	0.16	0.56	30.54
2010	2.86	3.80	4.41	11.29	5.57	5.85	7.94	3.28	1.81	0.08	0.35	0.62	47.86
2011	4.29	5.41	11.19	1.71	5.08	12.30	4.22	1.37	1.62	0.20	0.17	0.27	47.83
2012	3.25	4.53	1.67	5.81	3.42	12.10	5.09	0.66	1.78	1.16	0.11	0.10	39.68
2013	2.41	8.90	11.11	2.88	1.73	3.64	1.87	0.85	0.46	0.06	0.23	2.07	36.21
2014	0.14	1.32	0.61	0.89	6.06	5.74	1.50	0.72	0.16	0.14	0.17	2.45	19.90
2015	5.56	4.15	10.72	1.13	7.82	2.20	4.06	0.25	0.13	0.19	0.57	0.68	37.46
2016	1.01	4.34	13.16	13.29	3.33	10.05	3.24	0.59	0.05	0.16	0.14	0.23	49.59
2017	9.9	7.7	7.55	13.05	13.21	7.35	5.92	1.03	0.52	0.17	0.11	0.66	67.17
2018	1.11	6.54	1.87	7.07	2.03	9.79	4.37	0.99	0.53	0.09	0.14	0.25	34.78
2019	0.7	4.89	5.69	8.31	15.63	5.5	2.09	3.14	0.07	0.09	0.61	1.16	47.88
2020	0.96	1.35	9.82	7.32	0.96	3.3	2.33	4.28	0.62	0.14	0.13	0.46	31.67
2021	0.34	3.34	3.51	8.41	6.06	5.09	0.9	0.35	0.47	0.68	0.18	0.99	30.32

Notes:

Data provided by J. Lema, Ferndale CA. Gauge located at 515 Shaw Ave. since October 1994, and at 1345 Main Street from October 1970 to October 1994.

Location prior to October 1970 was not determined.