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Sierra Valley Irrigation Review & LEPA Irrigation Efficiency Demonstration Program

Sierra Valley, Sierra and Plumas County California

Prepared for:

Sierra Valley Groundwater Management District
PO Box 88
Chilcoot, CA 96105

November, 2022

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1. EXECUTIVE SUMMARY

This report summarizes an evaluation of irrigation practices and potential water savings opportunities that could reduce groundwater pumping magnitudes in Sierra Valley, Plumas and Sierra Counties, CA. Three types of irrigation take place in Sierra Valley. Flood irrigation occurs over the largest areas in the valley, using diversion from primary stream sources and imported Little Truckee River water, managed under a Decree for the Middle Fork of the Feather River. Groundwater is also pumped for irrigation to center pivot and wheel line irrigation systems. In 2021 and 2022, approximately 50 center pivots and 20 wheel line systems were in operation. Some pivot- and wheel line-irrigated fields rely solely on groundwater, while others have a combined surface water and groundwater source. It is currently estimated that about 5,000 acres use groundwater sources for irrigation, and another approximately 3,400 acres are irrigated using a combination of groundwater and surface water sources. As reviewed in the GSP for Sierra Valley, groundwater pumping for irrigation over the past two decades has averaged about 8,500 acre-feet per year, but has varied between approximately 5,000 to 14,000 acre-feet per year, depending on wetness of the water-year, and availability of surface water (GSP, Chapter 2, p. 2-129; and GSP Appendix 2-7, p 97).

Almost all center pivots in Sierra Valley use traditional mid-elevation sprinkler application (MESA) systems. Potential improvements to irrigation efficiency on the MESA systems could reduce groundwater pumping in the valley. Low elevation precision application (LEPA) systems and low elevation sprinkler application (LESA) systems have shown 15-20% reductions in water use, as demonstrated in other western US agricultural areas - and successfully used for alfalfa irrigation in similar climate valleys. The LEPA systems require a retrofit from ~9 ft-spaced 4 ft-height MESA sprinklers to close-spaced (~30 inches) sprinkler emitters (bubblers) suspended approximately 1-1/2 ft above the ground. LEPA systems run on 6 to 10 psi pressures - a significant reduction in pressures from what is required for MESA operation (~35 psi). LESA systems use spray emitters rather than bubblers, typically operating on 15 psi. The advantages provided by LEPA and LESA is reduced wind drift water losses and lowered evaporation losses. In additional to water savings, LEPA and LESA systems also reduce electrical power costs, potentially improve crop yields, and for LEPA, potentially lower gopher problems caused by land surface flooding. Combined with soil moisture monitoring technology, deep percolation losses due to over application or non-uniform application of water can also be reduced. LEPA may however cause issues with ponding and runoff due to reduced application times, sloping ground or clay-rich soils, and LESA systems may be more effective for use in some fields in Sierra Valley.

Other options to enhance irrigation efficiency include:

- conversion of wheel lines to linear or center pivot systems,
- soil moisture monitoring to adjust water application to better match crop water demands,
- variable-frequency drive (VFD) pump control implementation to minimize over-watering in the spring when the water table is higher
- minimize water conveyance piping leaks and conveyance losses, where possible, and
- improve soil moisture retention.

We estimate that achieving a 20% irrigation efficiency improvement for ~90% of the groundwater irrigated fields in Sierra Valley would save approximately 1,500 acre-feet per year as a long-term average. This is an optimistic projection, and under more conservative analysis, a 15% irrigation efficiency improvement for ~80% of the groundwater irrigated lands would produce about 1,000 acre-feet per year savings. This magnitude of groundwater pumping reduction would be a significant

advancement toward achieving groundwater sustainability in the valley, where it is estimated that the long-term pumping reductions, or enhanced aquifer recharge, need to overcome aabout 1,500 to 2,500 acre-feet per year long-term deficit that is resulting in long-term groundwater level declines.

2. INTRODUCTION

2.1 Purpose of this Document

This document summarizes existing agricultural irrigation practices in Sierra Valley, focusing on groundwater sourced irrigation and potential irrigation efficiency improvements to reduce groundwater pumping. Details of a demonstration program for irrigation efficiency improvement using a LEPA sprinkler system are presented. Guidelines for data collection for the LEPA demonstration program are contained within this document.

This technical document can serve as guide for continued evaluations, demonstration programs, and advancement of implementation of projects and management actions related to agricultural water use efficiency improvement to help reduce groundwater use over the coming years, to meet the goals of the Sierra Valley Groundwater Sustainability Plan (GSP). The GSP document is available at the Sierra Valley Groundwater Management District website, https://www.sierravalleygmd.org/sierra-valley-groundwater-sustainability-plan.

This evaluation has been funded by a grant from the California Department of Water Resources (DWR) for development of the Sierra Valley GSP, made to the Sierra Valley Groundwater Sustainability Agency (GSA) with managing member organizations being the Sierra Valley Groundwater Management District (SVGMD) and Plumas County.

2.2 GSP Projects and Management Actions

Chapter 4 of the GSP provides details on identified potential Projects and Management Actions to advance the goal of sustainable groundwater use in Sierra Valley. Specially, Tier II Projects and Management Actions relate to potential future actions, whereas Tier I actions are on-going, with potential for augmentation. Under the identified GSP Tier II Projects and Management Actions, *Agricultural Efficiency Improvements* is a component and goal. Details of this proposed Project and Management Action are contained in Section 4.3.1 of the GSP, and is described as follows:

> *Project Description*: Achieving increases in irrigation efficiency through equipment improvements is anticipated to reduce overall water demand. This management action would include development of work plans tailored to individual ranches based on identifying viable alternatives for existing practices and initially conducting pilot projects to evaluate their effectiveness.

2.3 Acknowledgements

The McGinley team responsible for this evaluation and document would like to thank the Sierra Valley Groundwater Management District (SVGMD) and Plumas County for the opportunity to provide professional services on the important component of the newly adopted Groundwater Management Plan (GSP) for Sierra Valley. This project has been funded through a grant received from California Department of Water Resources (DWR), and we are thankful to the State for making it a priority to assist the Sierra Valley residents with the funding necessary to advance sustainable groundwater management in the valley. We would like to acknowledge the Sierra Valley DWR representative Ms.

Debbie Spangler for being an active and accessible resource over the course of all work related to GSP development and initial implementation steps.

The McGinley team would like to acknowledge the assistance of Mr. Jay Huebert, the SVGMD Meter Technician for taking us through the valley on multiple occasions, driving to all active wells and farms/ranching that utilize groundwater, and for gladly sharing his local knowledge with us. We would also like to thank the SVGMD Board members (Mr. Einen Grandi, Mr. Don Wallace, Mr. Dave Goioechea, Mr. Greg Ramelli, Mr. Paul Roen, Mr. Jim Roberti, and Mr. Dwight Ceresola) and local farmers who shared their knowledge of, and experience with, local farming and irrigation practices over the course of this study, and who openly discussed their observations and ideals. Appreciation is also extended to Ms. Jenny Gant, SVGMD Board Clerk for her day-to-day assistance and coordination.

We appreciate the input of all the GSP planning committee members during development of the GSP projects and management actions, and through the course of development of this document, including Ms. Judie Talbot, Ms. Kristi Jamason, Ms. Tracey Ferguson, and Ms. Laura Foglia and Ms. Betsy Elzufon from the Larry Walker and Associates GSP development team. We also appreciate the efforts and input of the GSP Technical Advisory Community members during initial discussions on potential implementation projects and management actions.

We would like to thank Mr. David Wagstaff, the regional Senninger representative for sharing information on types and models of LEPA and LESA products, and offering an initial conversion design for the Roberti Ranch Pivot #13. We further thank Ms. Megan Thomason with Agri-Lines for refining the LEPA conversion design and sharing ideas for an effective LEPA retrofit effort.

We especially thank Mr. Jim Roberti and the Roberti Ranch for agreeing to be the first participant in the LEPA Demonstration Program, an important first step to defining viable ways to improve irrigation efficiency and lessen groundwater pumping for agriculture in the valley.

3. BACKGROUND

3.1 Historical Irrigation Practices in Sierra Valley

Sierra Valley has been a farming/ranching valley since the initial settlement of the region in the 1850s and 1860s. Streams tributary to the Middle Fork of the Feather River were diverted to irrigate pastures and meadows, providing hay, dairy products, and beef to regional markets. An account of the settlement of Sierra Valley is presented in GSP Appendix 2-2.

Ranching and farming practices have continued into the 21st century. In the period from the 1940s to 1950s, artesian wells were installed to supplement surface water sources, and high-capacity irrigation wells were constructed in the 1960s and 1970s, concentrated on the east side of the valley. Concurrent with development of the wells, groundwater levels began declining in the valley. Many artesian wells on the valley floor ceased to flow in the mid-1960s (DWR, 1983).

In 1980, the Sierra Valley Groundwater Management District (SVGMD) was formed under statutory authority of SB 1391 to oversee the management of groundwater pumping in the valley. SVGMD has monitored volumes pumped, and monitored groundwater levels in the valley nearly since its inception, and in recent years, has limited drilling of new high-capacity wells in the designated northeast quadrant areas of the valley.

In 1981, water use in Sierra Valley was reported as 12,400 acre-feet (AF) pumped for agriculture, and 2,100 AF pumped for municipal and industrial uses (DWR, 1983). An estimated 63,200 AF of surface water was used for agriculture, and 50 AF for municipal and industrial purposes. Crops grown in 1981 were primarily alfalfa and grains, but also included modest amounts of potatoes, safflower, garlic, and turf grass (DWR, 1983).

3.2 Current Irrigation Practices in Sierra Valley

Since the 1980s, the use of groundwater has continued generally in a similar status to present day. Alfalfa became both a crop to support local livestock, and for export to dairy operations in the Central Valley and beyond. Pasture and hay grasses continue to support the local cattle industry.

The short growing season and harsh winter conditions in this inter-mountain Sierra Nevada valley limit the crops that are suitable to grow. The valley has proven to be well-suited to grow high-quality alfalfa. As defined in the GSP and by Bachand et al (2020a), groundwater use for agriculture has ranged between approximately 5,050 to 13,600 acre-feet per year (AFA) over the 20 year studied period with a long-term average of 8,500 to 8,600 AFA. Variability in groundwater usage relates to both climate variability, moisture received in the spring, and availability of surface water into the summer. It is presently estimated in the GSP that overdraft of groundwater is a minimum of 2,500 AFA, as a long-term average, in excess of a sustainable groundwater yield.

Today, approximately 95% of groundwater pumped from wells in Sierra Valley is used for agriculture, with the remaining being used for municipal supply in Loyalton and Sierra Brooks, along with smaller domestic, stock watering, industrial and commercial uses. Existing agriculture in Sierra Valley continues to produce forage crops for cattle and the dairy industry, which includes flood-irrigated pasture, cultivated alfalfa, grass hay, and grains as rotation crops.

Irrigated land areas presented in the GSP are derived in part using 2013 satellite imagery, and supported by a numerical flow model developed for the 2003 to 2020 timeframe. Estimated groundwater pumping in this timeframe averaged 8,460 AFA for agriculture and 490 AFA used for municipal purposes.

Updated irrigated areas were developed based on June 2021 satellite imagery, with 2021 areas under irrigation summarized in **Table 3.1.** Irrigated lands total approximately 33,350 acres, of which approximately 24,950 acres are interpreted to be surface water irrigated fields, meadow and pasture. The estimated area irrigated by groundwater or a combined surface water and groundwater source is 8,400 acres. Irrigation areas, partitioned by interpreted sources of water (surface water, groundwater, or combined surface and groundwater) and apparent type of irrigation (center pivot, wheel line, or flood), for year 2021 are shown in **Figure 3.1**.

In Sierra Valley, most groundwater is pumped to center-pivot irrigation systems of wheel lines. Almost all center pivots use mid-elevation spray application (MESA) sprinkler heads. MESA sprinkler head spacing is ~9 ft, and sprinkler height is ~4 ft above land surface. Some center-pivots are equipped with end-guns to expand the irrigated area. These end-guns are high-capacity impact sprinkler heads located at the top of the pivot line. Three pivots at the Green Gulch Ranch in the northern part of the valley operate using a low-elevation spray application (LESA) system. A single span of MESA pivot systems was converted to LESA systems on the Grandi Ranch and the Goodwin Ranch has a LEPA conversion for testing done by Bachand et al (2020b). In 2021, it is estimated that 4,085 acres were irrigated using center-pivot systems.

Wheel line irrigation systems typically have one impact sprinkler head located on each span between the wells. The lines are moved across the field, advanced forward in increments of approximately 40 to 60 ft, on a daily to several-day frequency. In 2021, it is estimated that 728 acres were irrigated using wheel line systems.

Only a small amount of pumped groundwater is used for flood irrigation, covering approximately 229 irrigated acres in 2021. A majority of flood irrigation in Sierra Valley is conducted using surface water resources. These include Little Last Chance and Smithneck creeks on the east side of the valley, Cold Stream and imported Little Truckee River water to the southwest end of the valley, and a number streams feeding the south and west side of the valley (West Side Group) including Fletcher, Berry, Hamlin, and Bonta creeks. Surface water diversion and irrigation deliveries are regulated by a state appointed Water Master under the Middle Fork of the Feather River Decree (1939).

Approximately sixty high-capacity wells are currently in use, and approximately 25 high-capacity wells are registered as inactive with SVGMD, as shown in **Figure 3.1**. In 2021, approximately 51 center-pivots were in operation, 8 of which were half or partial pivots (operating over a half or part of a circular area). The remaining pivots are full circle with irrigation areas ranging from as small as 36 acres to as large as 217 acres, and the majority covering approximately 125 acres.

It is estimated that at least twenty wheel line irrigation systems were in use in 2021, irrigating fields of varying sizes, but typically areas that are smaller than those irrigated under center pivots. The wheel lines are generally used to irrigate rectangular fields, and in some instances, to irrigate corners outside the footprint of the center pivots.

In 2022, irrigation practices were observed to be similar to 2021, with approximately 50 center-pivots in operation, using mostly MESA sprinkler systems, as described above.

Table 3.1 – Summary of Estimated 2021 Irrigated Area in Sierra Valley

Irrigation Method	Water Source	Irrigated Area (Acres)
Center Pivot	Groundwater	4,085
Wheel Line	Groundwater	728
Flood	Groundwater	229
Center Pivot	Mixed Surface Water and Groundwater	3,174
Wheel Line	Mixed Surface Water and Groundwater	183
Flood	Surface Water	24,950

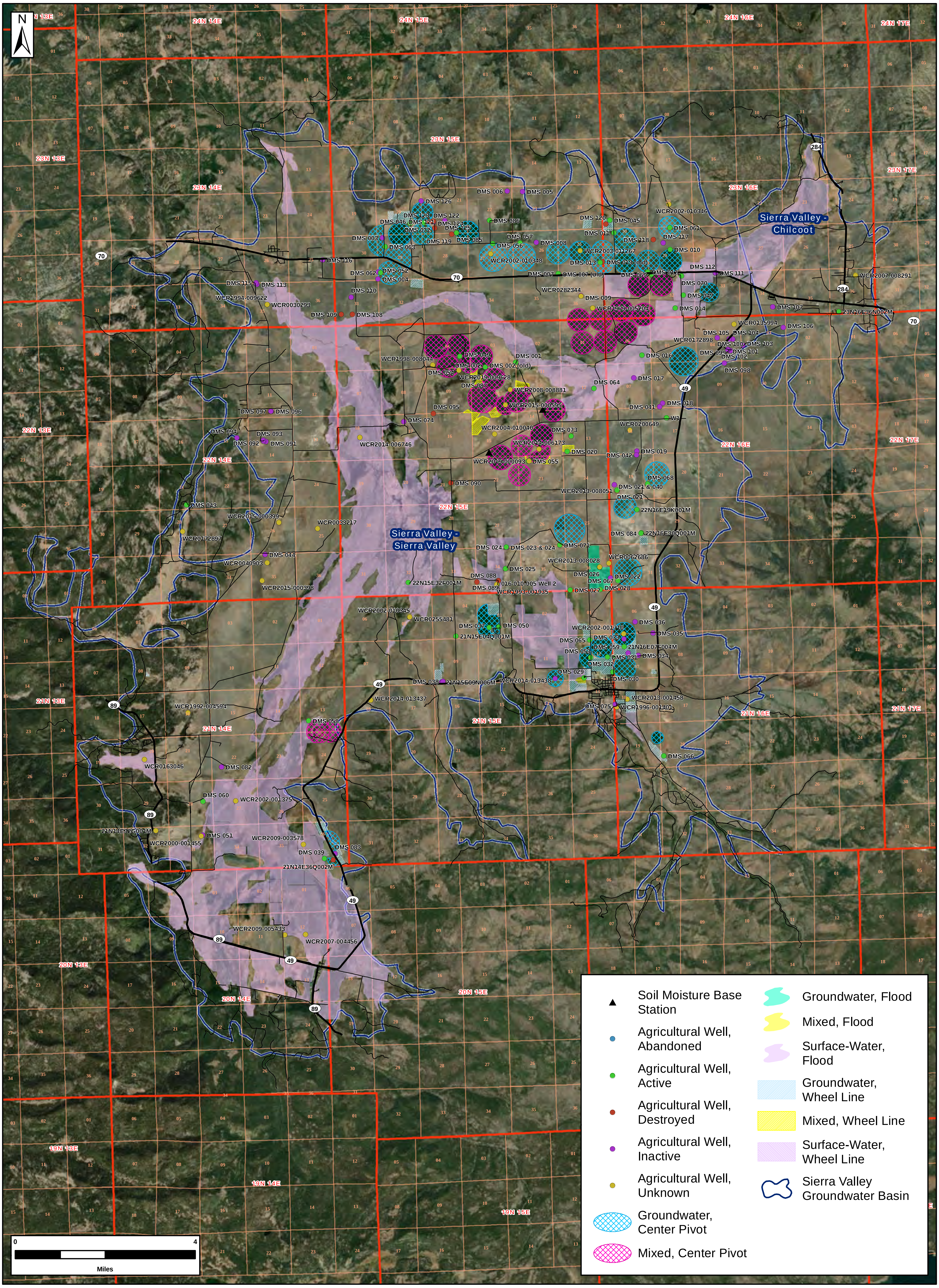

FIGURE 3.1

TITLE:

SITE MAP
-SHOWING-
Irrigation Water Sources
Sierra Valley, California

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FILE: Fig Irrigation Water Sources_11x17

COORDINATE SYSTEM: NAD 1983 UTM Zone 10N

JOB NO.: SVGMD001

DATE: 9/28/2022

REF.	DESIGNED	HC	CHECKED	DS	REVISION: -
	DRAWN	HC	APPROVED	DS	

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4. IRRIGATION METHODS

4.1 General Irrigation Types

There are three different types of irrigation methods currently utilized in Sierra Valley; flood irrigation, wheel line irrigation, and center pivot irrigation. Flood irrigation, also known as surface irrigation, consists of rapidly applying water directly to the ground surface and allowing the water to flow along the ground and among the crops. This traditional irrigation method is inexpensive and requires very little technology and equipment while also limiting evaporation. However, flood irrigation may lead to application of water in excess of that required by the crop, due to runoff at the edges of the irrigated areas and excessive deep percolation past the root zone.

Wheel line irrigation, also known as side-roll or wheel-move irrigation, is an irrigation method that consists of applying water through sprinklers that are mounted to a long lateral pipe that is connected to a water source. The lateral pipe moves water from the source to the sprinkler heads during irrigation. This lateral pipe is mounted on a row of wheels that will be periodically moved across a field during irrigation in order to evenly irrigate the crop.

Center pivot systems are mechanized irrigation systems used to irrigate a circular field. This method utilizes a center pivot point located in the middle of a circular field which all other components of the system rotate around during irrigation. Overhead sprinklers are hung from a horizontal pipe via drop hoses. These sprinkler heads are rotated about the center pivot point via drive units at certain distance increments from the center. As everything rotates about the center pivot point, the sprinklers irrigate the crops below.

4.2 Center Pivot Irrigation Sprinkler Types

Mid-Elevation Spray Application, or MESA, is a commonly used irrigation technique when employing a center pivot system and in wide use throughout Sierra Valley. Sprinkler heads are evenly spaced about 9' apart and suspended approximately 4' above the ground, halfway between the overhead pipeline and the ground surface by drop hoses. Water is applied to the crops below through these suspended sprinkler heads while the main line and sprinklers rotate about the center pivot point via the drive unit in between each span.

The Low Elevation Sprinkler Application (LESA) and Low Energy Precision Application (LEPA) are both alterations to the traditional MESA configuration of sprinklers used on center pivot irrigation systems (Peters et al., 2016b). A comparison of MESA, LESA and LEPA sprinklers is illustrated in **Figure 4.1**. The LESA configuration is very similar to the MESA configuration but the sprinkler heads are suspended at a lower elevation, approximately 1 to 1-1/2 feet off the surface of the ground, and are more closely spaced at about 30" apart. **Figures 4.3a and 4.3b** show examples of LESA sprinkler heads. The lower sprinkler heads help reduce the amount of water lost to evaporation and wind drift.

LEPA sprinkler emitters are similar to the LESA sprinklers; however, it uses bubbler heads rather than sprinkler heads which applies water directly onto the soil surface at very low pressure by bubblers that operate at or just above ground level (Neibling et al., 2014) (**Figures 4.2a and 4.2b**). LEPA systems further minimize wind drift, droplet evaporation and canopy evaporation.

While LESA and LEPA are general sprinkler styles, various vendors have different LEPA and LESA sprinkler emitters that may be tailored for field conditions. Field-scale testing of these differing LEPA and LESA products would be beneficial under expansion of the LEPA Demonstration Program in

Sierra Valley.

Figure 4.1 – Illustration of MESA, LESA and LEPA Sprinkler Irrigation (Peters, et al, 2015)

Figure 4.2a – Illustrations of LEPA sprinkler emitters (nelsonirrigation.com)

Figure 4.2b – Illustration of wide-spray (30”-60”) LEPA Sprinkler emitter (senninger.com)

Figure 4.3a – Illustrations of LESA sprinkler emitter (nelsonirrigation.com)

Figure 4.3b – Illustration of LESA low drift sprinkler emitter (senninger.com)

5. IRRIGATION EFFICIENCY

5.1 Definition of Irrigation Efficiency

The term *irrigation efficiency*, as used in this document, is synonymous with the term *water application efficiency*. Simply stated, the irrigation efficiency is that percentage of applied irrigation water that satisfies the crop water demand (evapotranspiration).

Irrigation efficiency is affected by multiple factors including irrigation system management, water distribution methods, crop use rates, weather conditions, and soil characteristics. Additional water application exceeding crop water demand is also required to prevent salt buildup in the root zone and sustain agriculture (leaching fraction). The more efficiently that an irrigation system applies water to the crop root zone, while avoiding losses to other variables, the higher the irrigation efficiency. Irrigation efficiency can approach 100%, but cannot achieve 100% due to variables the necessary leaching fraction outlined above.

5.2 Key Variables Affecting Irrigation Efficiency

Key variables of irrigation water loss are as follows, and as illustrated in **Figure 5.1**.

- Droplet evaporation
- Wind drift
- Canopy evaporation
- Runoff
- Deep Percolation

Irrigation efficiency can be improved by accomplishing more uniform distribution of water to soils, reducing losses to wind drift, minimizing droplet evaporation, minimizing canopy interception and evaporation, minimizing deep percolation past the root zone in excess of a necessary leaching fraction, and preventing runoff from the irrigated area, with a goal of applying just the right amount of water to meet the crop evapotranspiration (ET) requirement. Due to non-uniformity of applied water and natural soils variability, achieving perfect efficiency is not possible, and when approached, will result in some percentage of the crop experiencing distress and crop loss or lowered yield. The highest practical limit to irrigation efficiency is approximately 90-95%. Common irrigation efficiency for flood irrigation is 50-60%, for linear wheel line sprinkler systems 60-70%, and for center-pivot sprinkler systems 75-85%.

Every farm and plot irrigated has it unique characteristics, and irrigation efficiency ranges can vary. For flood irrigation practices, canopy evaporation and wind drift become negligible, however, uniformity of water application can be challenging, resulting in significant deep percolation or runoff. Wheel lines generally have one high-pressure impact sprinkler head on each piping span between the wheels. Because the water is sprayed further through the air as compared with a center pivot system, irrigation water is exposed to greater droplet evaporation and wind drift, and the uniformity of irrigation water application may be lower than a center pivot system with its more closely spaced sprinkler heads. But wheel lines generally improve uniformity of water application over flood irrigation.

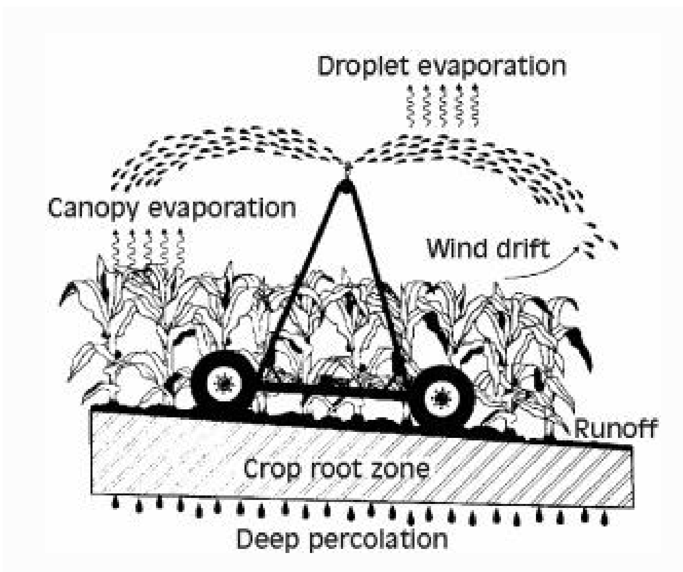

Figure 5.1 - Components of applied irrigation water loss (from Kranz, 2022)

5.3 Irrigation Timing and Water Application Management

Irrigation timing and rate of application are managed by the farmer, commonly using physical inspections of the soils. Soils moisture sensors can aid in understanding of moisture retention and irrigation requirements, rapidly providing information on water content up to the depth of placed moisture sensors. For alfalfa, a relatively deep-rooted crop, soil moisture sensor depths between 12” to 30” are common.

5.3.1 Pump Control Systems

A current limitation to water application management in Sierra Valley is the use of conventional pump control systems, rather than variable frequency drive (VFD) pump controls. When well pumps are turned on in the spring, groundwater levels in the aquifer are shallower than later in the summer levels. The seasonal variability of pumping water levels affects the rate of flow being produced by the pumps. When the pump is lifting water a greater distance to get to land surface, the volume produced will be lower. The result is that the irrigation wells produce higher flow rates in the early season, when the required water by the crop is not as a great, as contrasted with summer crop requirements, when aquifer water levels have dropped and the well pumps are producing lower volumes of water. This dynamic tends to result in over-application of water in the spring.

The over-application early in the irrigation season can be overcome by frequent adjustments to flow regulation valves, but partially closing a valve creates back-pressure and is a waste of electrical power (with pump operating against unnecessary head). Manual adjusting is also an imprecise approach to flow regulation.

VFD pump controls modulate the pump motor speed to match the desired flow rate produced from the pump, without valving and unnecessary power waste. In the early season, when water levels are shallower, the VFD will operate the pump motor at a lower speed, programed to deliver the desired flow rate from the well. As additional lift is required through the irrigation season, the VFD will increase the motor speed to maintain the desired water delivery. VFD control systems can thereby improve management of water delivery to the fields to better match crop water requirements, minimizing waste of water and electrical power. Currently, only a few irrigation wells in Sierra Valley are equipped with VFD pump control systems.

5.3.2 Deep Percolation Management

Deep percolation occurs in all irrigated agriculture, when a portion of applied water seeps downward past the crop root zone. As mentioned previously, sustained agriculture requires leaching of accumulated salts from the root zone (leaching fraction), and therefore some deep percolation is beneficial and necessary.

In Sierra Valley, deep percolation is not a lost water resource, rather it constitutes a source of shallow water table recharge, especially over the areas which are flood irrigated with surface water. Increasing irrigation efficiency for sprinkler systems will likely reduce this component of shallow water table recharge. However, the deep percolation below sprinkler irrigated fields is not identified as a primary source of recharge to the shallow water table aquifer (primary recharge sources are flows of the streams and creeks that cross the valley floor augmented by the use of surface waters for flood irrigation).

Improving uniformity in irrigation water application, and use of soil moisture sensors to guide the timing and volume of water being applied, are two approaches that can result in better managing deep percolation. To the extent that the use of soil moisture sensors can be encouraged and supported in Sierra Valley, water savings and irrigation efficiency improvements can be realized for center pivot and wheel line systems.

5.3.3 Soil Moisture Retention

Improving soil health can reduce irrigation water demand over time, by improving moisture retention in the root zone, and minimizing excessive deep percolation or runoff. Soil health is judged by a combination of physical, chemical, and biological characteristics. Some of the characteristics important for water conservation are (1) improving soil organic matter, (2) improving available water holding capacity, and (3) improving or maintaining soil structure (GAO, 2019). Increasing organic matter in soils and potential use of soil conditioners could be considered for improved soil moisture retention in Sierra Valley, perhaps conducted on a pilot / demonstration scale, and under guidance of a soil agronomist.

6. REVIEW OF LEPA IRRIGATION TECHNOLOGY

6.1 Studies and Implemented Systems

LEPA systems are not new technology. Bordovsky (2018) reported that LEPA technology was developed in the late 1970s to address the depletion of irrigation water from the Ogallala Aquifer and the sharp increase in energy needed for pumping in the Texas High Plains. Lyle and Bordovsky published an evaluation of LEPA systems in 1983 (Lyle and Bordovsky, 1983). In their evaluation they determined that the LEPA system had superior application efficiency, distribution efficiency, water use efficiency and energy savings potential as contrasted with furrow and traditional sprinkler systems.

Buchleiter (1992) reported on the effectiveness of LEPA systems on center pivots to realized potential energy and water savings, looking at water application depth and uniformity. He noted that LEPA systems experience runoff issues for slopes greater than 3%, but performed well on fields with less than 1% slope.

Schneider (2000) reviewed published research on LEPA systems, generally observing that "*with negligible runoff and deep percolation, reported application efficiencies are in the 95 to 98% range for the LEPA sprinkler method*."

Peters, et al (2015) reported on LEPA and LESA systems from testing on six different pivots in Nevada, Idaho, and Washington. Crops being grown included alfalfa, mint, grass seed, beans, wheat, oats, and silage corn. As part of their studies, one span on each pivot was converted from MESA to LESA/LEPA technology. The spray heads were placed at 12 inches above the ground surface, and the spacing was less than or equal to 5 ft apart. Soil moisture sensors at multiple depths in both the LESA and MESA portions of the pivot were compared. As reported in their paper, "*the data clearly demonstrate that the LESA was much more efficient and more water reached the soil*" and "*all of the farmers expressed enthusiasm for the technology and plans to convert entire pivots to LESA*".

As summarized in Peters, et al (2016a, 2016b), "*LEPA and LESA are alterations on a center pivot where the sprinklers are moved much closer to the ground, the spacing between sprinklers is reduced (more sprinklers), and water is emitted at very low pressures. It saves water (18%), it saves energy (less water pumped and pumped at a lower pressure), and it helps growers get better yields especially in areas where water is limiting. However, it has an increased propensity for runoff, and the sprinklers operating below the top of the canopy can require some management changes.*"

In a two-year irrigation study, Molaei, et al (2020) report using 15% less water under LEPA/LESA systems to grow equal yields of spearmint and peppermint in eastern Washington, as compared with traditional MESA systems. Likewise, Sarwar, et al (2019) report 21% more water reaching the ground using LESA as compared with MESA, with a 16% increase in water application efficiency, in an eastern Washington study. The effectiveness of the LESA method versus MESA was field tested in 2013 in the Pacific Northwest, with results indicating a 15% to 20% reduction in total water usage as well as a 30% reduction in electrical energy consumption for LESA as compared to conventional MESA (Stroh, 2018).

Farmers in Diamond Valley, Nevada have been testing LEPA systems, and are targeting a 20% water use reduction by converting from MESA to LEPA systems (Wharton, 2021). Diamond Valley provides a good proxy for Sierra Valley, with a valley floor elevation of approximately 5,800 ft above mean sea level (amsl) and a principal crop of alfalfa grown for the California dairy industry. Diamond Valley has a serious groundwater overdraft condition and has implemented a 30-year basin-wide groundwater management plan to reduce groundwater pumping by one-half over recent conditions. Irrigation efficiency improvements are an important component of plan implementation, along with establishing a progressive reduction in the duty (acre-feet, annually) of water right shares over the plan horizon.

Two farmers in Fish Lake Valley, located on the California-Nevada Stateline (Mono County and Esmeralda County) were contacted to discuss wide-scale conversions from MESA to LEPA that have been made in over the past 10-years (D. Smith, 2022 personal communications, Ralph Keys and John Maurer). There are approximately 110 active pivots operating in Fish Lake Valley, for production of alfalfa, in a climate that shares similarities with Sierra Valley (valley floor elevation of ~4900 ft amsl). It is reported that approximately 80% of the active pivots in Fish Lake Valley have now been converted to LEPA systems, with the following benefits being observed:

- Reduced water use
- Reduced electrical power
- Increased crop yields
- Decreased problems with gophers

Other programs are ongoing throughout the western US to both evaluate and implement conversion from traditional MESA pivot irrigation to LESA and LEPA systems, for the purposes of conserving groundwater resources where crop irrigation uses center pivots. Efforts are ongoing in Utah (Southern Utah University, 2021), Idaho, Oregon (supported by the Bonneville Power Administration), New Mexico, Washington, and Nevada.

6.2 2018-2019 LESA Irrigation Efficiency Study in Sierra Valley

Bachand et al (2020) conducted a test of LESA sprinkler systems on two irrigated fields in Sierra Valley in 2018 and 2019, one in the south at the Grandi Ranch, and the other in the north part of the valley on the Goodwin Ranch. In this study, one span of a MESA equipped pivot was converted to close-spaced LESA sprinklers on the Grandi Ranch, and one full conversion was made on the Goodwin Ranch. Soil moisture, alfalfa yield, and crop quality were measured at the test plots. As summarized in their presentation to the SVGMD Board in June, 2020, the following observations were reported from this study.

<u>Standard (MESA) Irrigated Fields:</u>

- Used slightly more water (7%)
- Soil moisture declined less throughout the season
- Appeared to have more operational flexibility (can catch up)
- Yields were similar
- Hay yield quality tended toward premium at both fields

<u>LESA Irrigated Fields:</u>

- Used slightly less (7%) water
- Soil moisture declined more throughout the season
- Appeared to have less operational flexibility (more difficult to catch up)
- Yields were similar
- Hay quality tended toward lower, though still good to premium

Additional operational observations for the LESA conversions were as follows.

- System maintenance important for irrigation efficiency
- Nozzle emitters clog easily, can severely affect irrigation uniformity
- Pump rates decrease during irrigation and throughout season in response to local groundwater level declines
- Pivot operation affects water distribution and irrigation uniformity
- Higher pivot speeds likely lead to greater ET losses (could not be measured here)
- Changing pivot speeds affects irrigation uniformity
- On half- and quarter-field pivot systems, pivots stop at the end of the run but continue pumping
- Affects irrigation uniformity
- Automatic pump switch would increase uniformity and water use efficiency

The following conclusions and recommendations regarding LESA sprinkler systems were made.

- May provide slight decrease in irrigation water use
- Can reduce crop quality
- May be more likely to lead to greater soil moisture declines throughout the growing season
- May be less effective in overcoming soil moisture deficits due to higher design efficiencies
- Valves are more likely to stray from design specifications
- Anecdotal information suggests LESA systems require greater maintenance

Other general observations regarding irrigation practices in Sierra Valley were as follows.

- Groundwater levels (short-term and long-term) affect pumping rates
- Effective pivot system maintenance is required for optimum irrigation system performance
- Pivot systems design and operation affect their performance
- Slower pivot speeds more likely to reduce transpiration losses
- Slower pivot speeds could lead to greater water losses past the root zone
- Alfalfa is considered deep rooted crop so may be able to recover deeper water if trained
- Changes in operation (e.g., pivot speed, clogging) affect water distribution and likely irrigation use efficiencies
- Improvements in irrigation water use may be achievable with improved pivot operation and appropriate soil moisture monitoring (including to depth), and may be more cost effective than transitioning from MESA irrigation systems to LESA systems.

The LEPA Demonstration Program being initiated for Sierra Valley will provide larger-scale (field-scale) testing of LEPA technology. The LEPA bubbler emitters have larger apertures as compare with LESA sprinklers, which may lessen emitter clogging issues observed by Bachand et al (2020). The Nelson LEPA emitter also has easy flush functions, which should aid in clogging prevention.

6.3 LEPA vs. LESA Comparative Overview

The drawbacks to the MESA systems include water losses due to wind drift and evaporation as well as increased energy due to high water pressures needed for operation (~35-40 psi) and additional volume of water being pumped to meet crop water demands (Peters et al., 2016b). Both LESA and LEPA aim to mitigate these drawbacks by increasing the efficiency of the center pivot or linear-moving irrigation system.

LEPA and LESA involve applying water directly onto the soil surface at very low pressure by sprinklers or bubblers operating just above ground level (Neibling et al., 2014). The goal of the LEPA method is to maximize the efficiency of center pivot or linear-movement irrigation systems by limiting water losses to evaporation and wind drift while also reducing the amount of energy and water needed for pumping and operation. The low operating pressure (~6-10 psi) significantly reduces the energy needed for pumping and operation while the direct application of water to the soil surface limits the possibility of water losses to evaporation and wind drift.

LEPA can cause issues with ponding and runoff due to the reduced application time, notably for sloping ground or clay-rich soils (Peters et al., 2016b). There are multiple mitigation techniques that can be employed to address this issue. Furrow diking is an effective way to hold water locally until it can infiltrate into the soil (Bouchardt and Jones, 2003). Employing tilling methods to loosen the soil in order to increase water storage and promote quicker and deeper infiltration will also help mitigate ponding and runoff (Peters et al., 2016b).

LESA involves applying water very close (~1 to 1-1/2 ft) to the soil surface through suspended sprinklers or spray heads. This irrigation method has the same goal as LEPA to maximize the efficiency of center pivot or linear-moving irrigation systems by limiting water losses to evaporation and wind drift while also reducing the amount of energy and water needed for pumping and operation. However, while similar to the LEPA method, LESA applies water more uniformly across the soil surface than LEPA (Peters et al., 2016b). This is due to the slight spreading of the water from the sprinkler head above the soil surface. The greater degree of uniformity leads to fewer issues with crop germination, ponding, and runoff than LEPA (Peters et al., 2016b). It also negates the need for furrow dikes throughout the field which allows for more flexibility with a wide variety of crops, row orientations, and tillage methods (Peters et al., 2016b).

LEPA and LESA are very similar irrigation methods and ultimately have the same end goal of maximizing efficiency and reducing excessive electricity and water usage. Hesitation to switch over from MESA may come from a reluctance to purchase additional sprinklers and hoses (Peters et al., 2016b). However, savings originating from energy and water use reduction can cover the costs of the additional equipment. The largest potential for profit is the ability maintain or improve crop yields in areas that are water short or have large losses to wind drift or evaporation (Peters et al., 2016b). In the case of Sierra Valley, however, the objective is to reduce use of groundwater for irrigation, and any energy savings or crop yield improvements are ancillary to the primary goal of achieving water savings.

In summary, the data clearly demonstrate that the LESA and LEPA are much more efficient with more water reaching the soil as contrasted with traditional MESA systems that are primarily in use in Sierra Valley. LEPA and LESA systems can help Sierra Valley farmers achieve the goal of increasing irrigation efficiency from center pivot systems by limiting water lost to evaporation and wind drift while also reducing the amount of energy and water needed for pumping and operation. Water application using the LEPA method is more precise and concentrated than either LESA or MESA due to the water being applied with the bubbler dribbles at a low pressure rather than being misted or sprayed over a broader area through the LESA or MESA methods. While this irrigation method increases the efficiency of the system, LEPA may cause issues with ponding and runoff due to the reduced application time as well as sloping ground or clay-rich soils, and LESA systems may be more effective for use in some fields in Sierra Valley. Field soils and slope conditions should be reviewed before considering which type of system may be more effective for MESA conversions. Additional testing of the various available LEPA and LESA sprinkler emitters and spacing is recommended for the Demonstration Program to aid in guiding future MESA conversations.

7. CROP TYPES AND WATER USE

Crop types also affect groundwater consumption. Conversion to economical alternative crops with lower water requirements could reduce pumping in the valley while maintaining a viable agricultural community. However, the climate in Sierra Valley, including freezing spring and early summer nighttime temperatures, limits potential of alternative crops that are economically viable. Also, many of the ranches engage in farming of forage crops in part to support cattle ranching operations.

Hemp has been tested on the Roberti Ranch, and there has been modest production of other crops, such as potatoes, garlic, and safflower, as reported for year 1981 by DWR (1983). The University of Nevada, Reno is researching sorghum as a low water use crop for northern Nevada, which has a climate similar to Sierra Valley, although with a somewhat longer growing season. Some northern Nevada producers are now growing teff, a low water use crop which can be used as forage and harvested as a gluten-free grain.

As alternative crops are identified, willing ranches can continue to work with local agricultural extension groups and conduct tests to further gauge the viability of alternative crops

8. SUMMARY - POTENTIAL IRRIGATION EFFICIENCY IMPROVEMENTS FOR SIERRA VALLEY

All ranches in Sierra Valley can improve upon existing irrigation efficiencies, thus reducing groundwater pumping. Identified areas for improvement are as follows.

- Convert MESA sprinkler systems to LEPA or LESA sprinklers
- Use of soil moisture sensors to refine applied water amounts and minimize deep percolation (percolation beyond the root zone)
- Avoid, if possible, irrigation during excessively windy conditions
- Irrigation system automation for improved water delivery to match crop water requirements, including monitoring of pivot motor speed and flow rates
- Use of Variable Frequency Drive (VFD) pump controls systems to modulate pumping rates from wells to meet crop water demand more effectively, minimizing over-application of water
- Reduce use of high-capacity end-guns, which are not as efficient in irrigating peripheries of the fields
- Convert wheel line irrigation to center-pivot irrigation, where possible
- Minimize use of groundwater for use in low-efficiency flood irrigation of pastures
- Improve water holding capacity of soils
- Reduce leakage from water conveyance pipelines, and unlined open ditches, where used for groundwater conveyance
- Conversion to low water use crops, as opportunities are identified

Center pivot irrigation technology is generally considered the most efficient means for irrigation water application. However, there are many variables of center pivot systems that effect how efficiently they are operated. Sprinkler modifications to existing MESA equipped pivots presents opportunities to increase irrigation efficiency and reduce groundwater pumping by conversion to LEPA and LESA equipment. Operations of all types of irrigation systems (pivot and wheel line) can also benefit from use of soil moisture monitoring equipment and VFD systems for pump control and flow regulation from wells.

Based on the research of other communities producing alfalfa in similar climate regions, we suggest that a goal of 20% improvement in irrigation efficiency be targeted for Sierra Valley. Achieving this goal will require:

- wide-spread conversion of MESA systems to LEPA and LESA,
- improved equipment and use of technology to monitor soil moisture to refine water application, and
- improved pump controls to regulate pumping rates and avoid early-season over-pumping and over-application of water.

Funding to support this ambitious but necessary transition to irrigation practices should be sought from available DWR implementation grant funding and other funding sources. With sufficient funding, this implementation component could be accomplished over the next 5 years. Assuming 90% of groundwater-irrigated fields can implement irrigation efficiency improvements as recommended, about one-half of the probable magnitude in groundwater pumping reduction required to achieve long-term sustainable groundwater conditions could be realized. Assuming a more practical level of implementation, is 80% of grondwater irrigated lands achieve a 15% improvement in irrigationation efficiency, 1,000 acre-feet annually of water use savings, over the long-term, could be realized. While irrigation efficiency improvements alone may not entirely achieve GSP objectives for groundwater pumping sustainability, it can provide a significant contribution and help preserve the historical culture of agriculture in the valley.

9. LEPA DEMONSTRATION PROGRAM

A LEPA demonstration program has been initiated in Sierra Valley. One MESA pivot retrofit has been completed at the Roberti Ranch Pivot #13. Roberti Ranch Pivot #10 is also equipped for monitoring of water use as a baseline for a comparable MESA system. The locations of Roberti Pivots #13 and #10 are shown in **Figure 9.1**. The baseline field was selected based on the Roberti's expectation of a similar crop yield as compared with yield from Pivot #13, under normal MESA irrigation conditions. OpenET (2022) reports the evapotranspiration (ET) water use by field utilizing satellite imagery and a number of published methods to convert vegetation indexes to estimate crop water consumption (ET). Contrasting ET for 2019, 2020, and 2021 are summarized in **Table 9.1**. ET curves for years 2019 to 2021 reflect a similar shape and magnitude, supporting similarity in irrigation practices for the two pivots (**Figure 9.2**). Field sizes are 124.0 acres and 145.8 acres for Pivots #10 and #13, respectively. The differences in field size will need to be accounted in crop yield comparisons during the demonstration study.

Soils types under each pivot are generally comparable sandy loam and loamy sand soils, with approximately 31 acres of clay soils at Pivot #10. The NRCS (2022) mapped soil types are shown in **Figure 9.3a** and **Figure 9.3b**.

The initiated demonstration program varies from the testing in 2018 and 2019 by Bachand et al (2020b) in that it: 1.) uses a LEPA rather than a LESA system, 2.) is set up to run for multiple years, 3.) is based on field-scale crop production rather than assessment on small test plots, 4.) will have primary data collection being made by the farmer, and 5.) will have a primary metric of metered water use. In the demonstration program, the farmer is expected to adjust and test operations of the LEPA pivot such as motor speed and number of irrigation days per cycle between cuttings, with the objective of producing similar field-scale crop yield while lowering applied water, made possible by improving the irrigation efficiency. It is hoped that the demonstration program initiated at the Roberti Ranch can be expanded, subject to additional funding, to include other geographic locations in the valley, other models of LEPA and LESA sprinkler emitters, and other potential styles of water saving irrigation equipment and practices (soils moisture sensor, soil moisture holding capacity improvements, VFD pump motor control systems, etc.).

Table 9.1 – Computed Annual Crop ET in OpenET (2022)

Year	Roberti Pivot #10 Computed ET (inches per season)	Roberti Pivot #13 Computed ET (inches per season)
2019	36	34
2020	33	34
2021	34	33

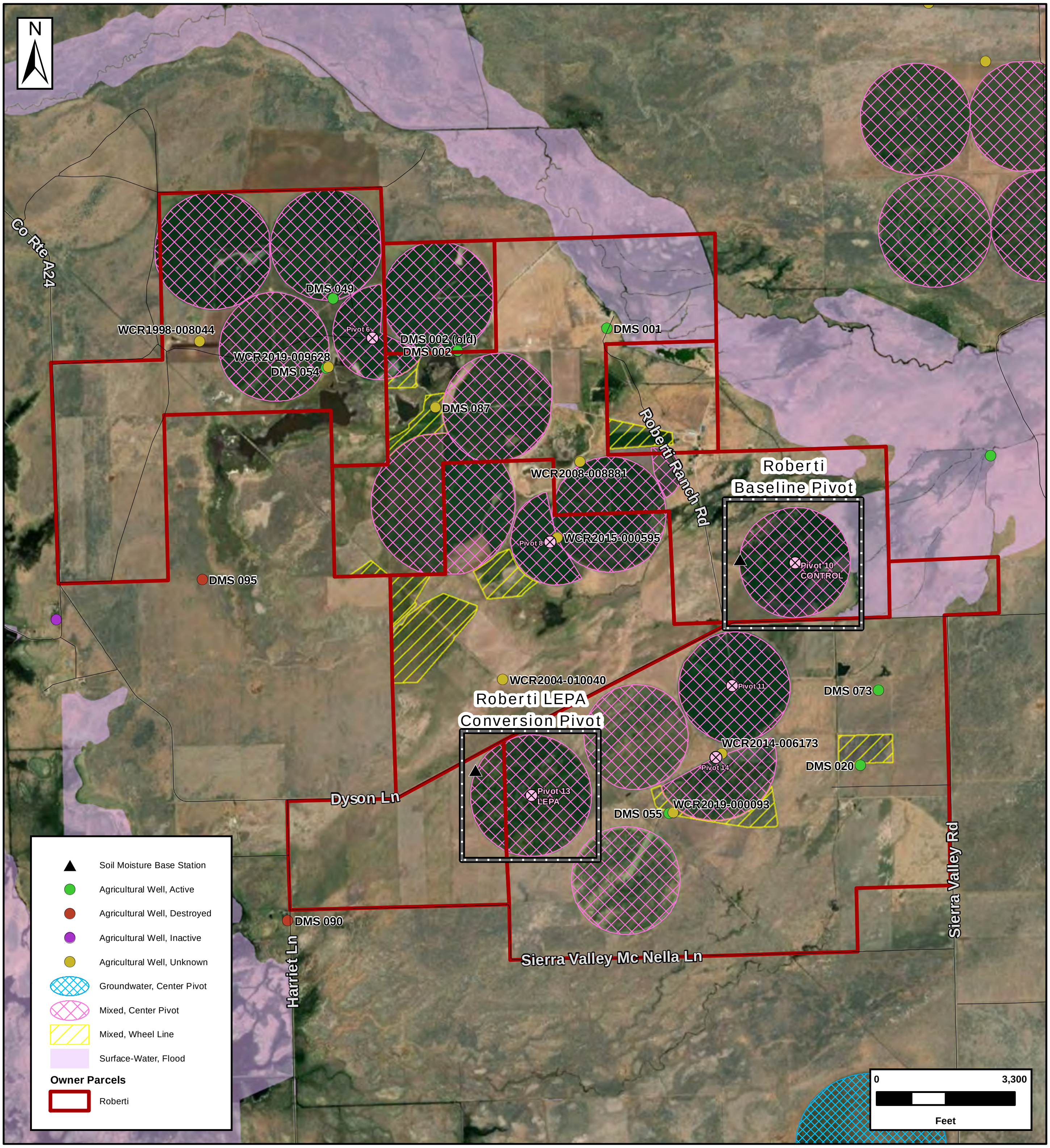

FIGURE 9.1

TITLE:

SITE MAP

-SHOWING-

Roberti Ranch Irrigation and Property Boundaries Sierra Valley, California

JOB NO.:	DATE:
SVGMD001	9/28/2022

McGinley & Associates
A Universal Engineering Sciences Company

FILE:
Roberti Ranch Property

COORDINATE SYSTEM:
NAD 1983 UTM Zone 10N

REF.					REVISION:
	DESIGNED	HC	CHECKED	DS	-
	DRAWN	HC	APPROVED	DS	

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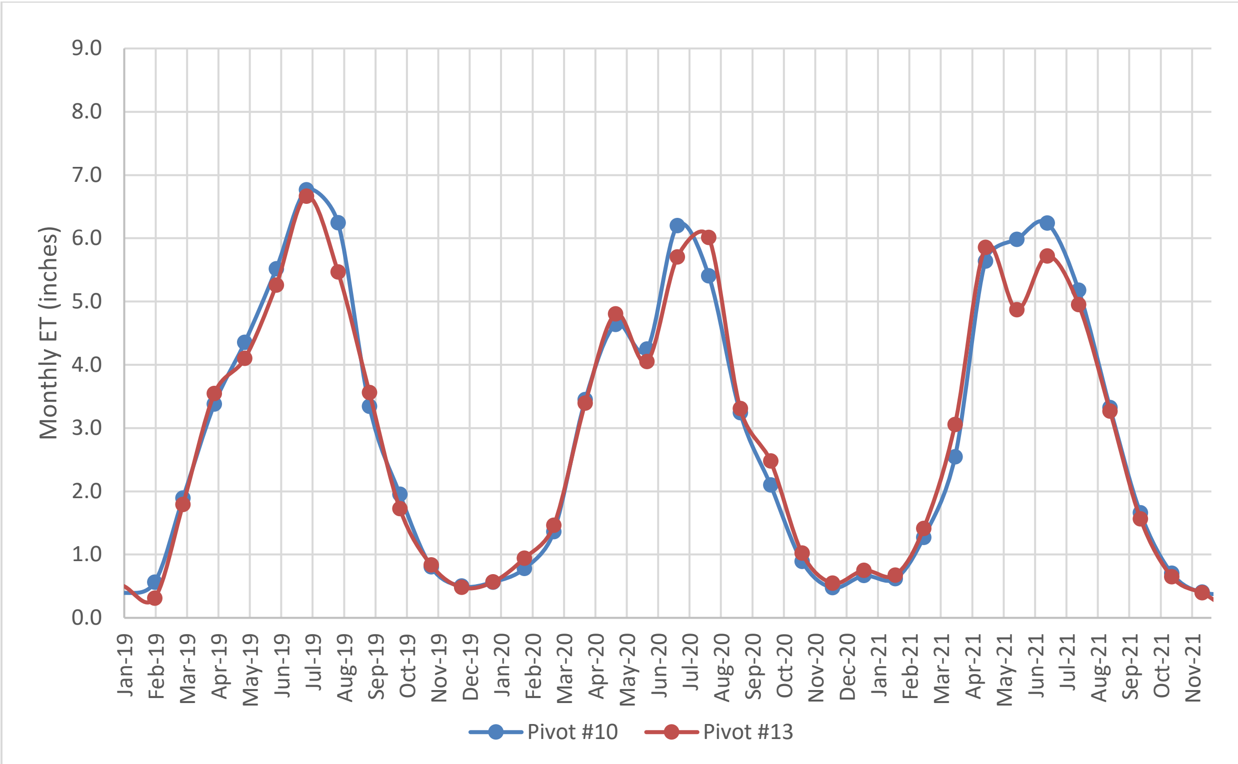

Figure 9.2 – Plot of 2019 to 2021 ET from Roberti Ranch Pivots #10 and #13

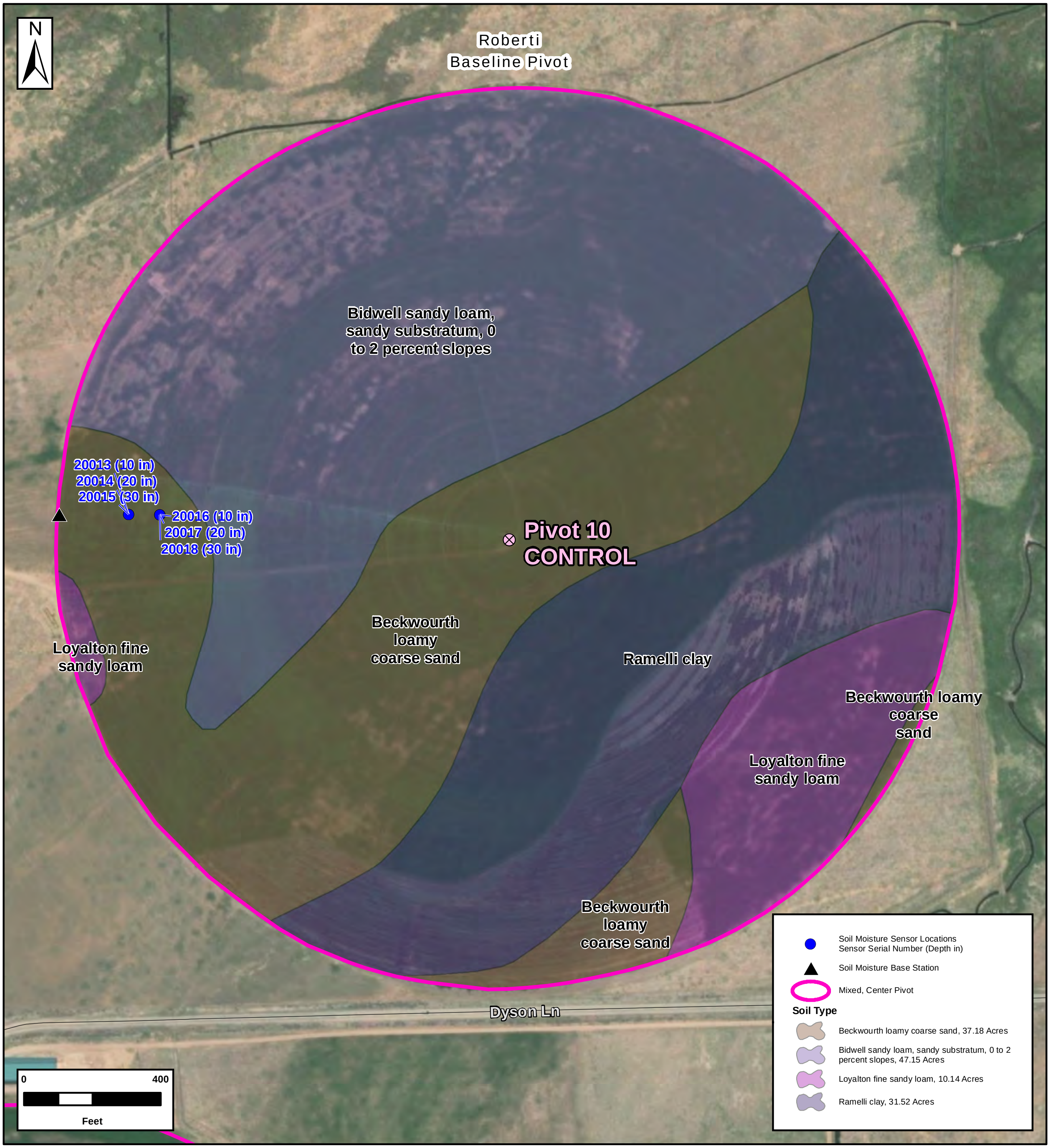

FIGURE 9.3a

TITLE:

PIVOT 10 SITE MAP

-SHOWING-

Roberti Ranch
Baseline Pivot
Sierra Valley, California

McGinley & Associates
A Universal Engineering Sciences Company

FILE:
Roberti Ranch Baseline Pivot (10) - Soil

COORDINATE SYSTEM:
NAD 1983 UTM Zone 10N

JOB NO.:	DATE:	REF.					REVISION:
SVGMD001	9/29/2022		DESIGNED	HC	CHECKED	DS	-
			DRAWN	HC	APPROVED	DS	

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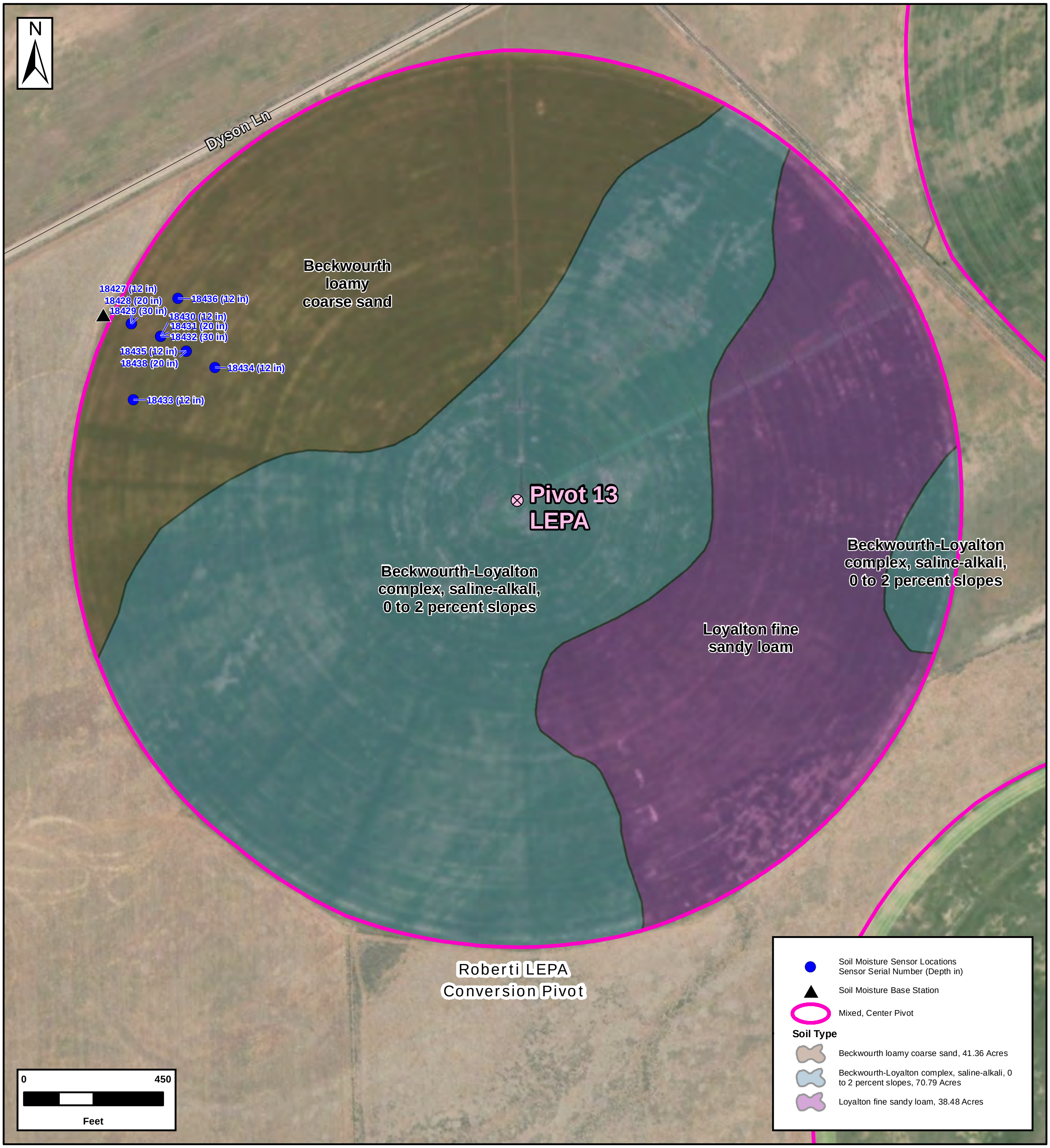

FIGURE 9.3b

TITLE:

PIVOT 13 SITE MAP

-SHOWING-

Roberti Ranch LEPA Conversion Pivot

Sierra Valley, California

JOB NO.:	DATE:
SVGMD001	9/29/2022

McGinley & Associates
A Universal Engineering Sciences Company

FILE:
Roberti Ranch LEPA Conversion Pivot (13) - Soil

COORDINATE SYSTEM:
NAD 1983 UTM Zone 10N

REF.					REVISION:
	DESIGNED	HC	CHECKED	DS	-
	DRAWN	HC	APPROVED	DS	

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9.1 LEPA Conversion – Roberti Ranch Pivot #13

In October 2022, Roberti pivot #13 was converted from a conventional MESA system to a close-spaced LEPA system. The equipment was provided by Agri-Lines, Winnemucca, Nevada. LEPA system design details are provided in **Appendix A**. Additional drops were added to accomplish an approximate 30-inch spacing. Sprinkler nozzles are Nelson 3030 Series Multi-Function 3NV LEPA (see cut-sheet in **Appendix A**). To avoid over watering on the first span from the pivot point, Nelson Orbitor series nozzles were installed (**Appendix A**). The conversion was made in preparation for the 2023 irrigation season. A photograph of the LEPA installation is included below, and additional photographs are contained in **Appendix A**.

Complementing the LEPA conversion, an inline totalizing flow meter was installed at the pivot point to accurately measure pivot water use (see photograph below). The flow meter is a Seametrics AG3000 magnetic meter, and flow meter documentation is provided in **Appendix B**.

Soil moisture sensors have been installed at several locations aligned with the 6th and 7th spans of the pivot, with sensor depths at 12, 24 and 30 inches. Locations of sensors are shown in **Figure 9.3a**. The soil moisture system is a wire-less Soil Scout Hydra100, which communicates to a base station at the edge of the field, and has telemetry data reporting to the vendor managed website. Soils moisture data can be view and recorded by operator via the website. Soil moisture equipment details are contained in **Appendix C**.

Photograph of Installed LEPA Sprinklers on Roberti Pivot #13

Photograph of Installed Magnetic Flow Meter at Roberti Pivot #13 Point.

9.2 Baseline Conditions Monitoring – Roberti Ranch Pivot #10

The baseline MESA pivot system on the Roberti Ranch (Pivot #10) was equipped with the same models of totalizing flow meter and soil moisture equipment to provide baseline data to compare with water use, soil moisture, and crop yield with the LEPA equipped field. The locations of the soil moisture sensers are shown on **Figure 9.1**. A photograph of the MESA equipped pivot is provided below.

Photograph of Roberti Pivot #10 Equipped with a Typical MESA Sprinkler System.

9.3 Field Parameters to be Measured

Throughout the LEPA Demonstration Program, various data regarding groundwater pumping, soil moisture, and operation of the center pivot irrigation systems will be recorded to closely track the performance of the LEPA systems in increasing the irrigation efficiency in Sierra Valley. The data to be recorded includes the total gallons of water used for irrigating between cuttings, soil moisture profile, number of pivot hours and days operated between cuttings, speed of the pivot motors and adjustments made during the irrigation season to improve water application and soil moisture, tonnage of crop yield from each cutting, and notes of the general quality of the crop if measured. Data will be collected and reported for each irrigation season, with the demonstration program expected to continue for 2 to 3 subsequent irrigation seasons to better define water use and LEPA system effectiveness over a range of climatic conditions. Data are to be collected from both the LEPA retrofitted pivot (Roberti Pivot #13) and the baseline MESA point (Roberti Pivot #10) to compare results. **Appendix D** contains a check list and format for data collection.

9.4 LEPA Data Reporting

After each irrigation season, a report will be drafted to refine the intended testing parameters for the following irrigation season. The report will include intended pivot motor speed adjustments and the planned number of irrigation days. The ultimate goal of the LEPA Demonstration Program is to verify that the LEPA irrigation system uses less groundwater water while maintaining an equivalent crop yield from year to year.

10. RECOMMENDATIONS FOR SIERRA VALLEY IRRIATION EFFICIENCY IMPROVEMENTS

The following recommendations are made to improve irrigation efficiency and reduce agricultural water use in Sierra Valley.

- Continue LEPA Demonstration Program over the next 2-3 irrigation seasons at the Roberti Ranch Pivot #13, and any other locations added to the Demonstration Program
- Expand the LEPA Demonstration Program at additional locations to test alternatives sprinkler types, better define optimal irrigation system operations, and define the variability in expectations due to farming practices, weather variability, soils and land slope variations, and crop conditions. As initiated at the Roberti Ranch, LEPA or LESA conversions for testing purposes should be paired with comparable baseline MESA field monitoring, so the performances may be adequately contrasted.
- As an initial recommendation, three addition center pivots can be retrofitted with LEPA systems to better define variances and expectations, and test different models of LEPA sprinkler heads
- As an initial recommendation, convert an additional three MESA pivots to an approximate 4 to 5-ft spaced modified LEPA or LESA system to contrast to the 30-inch close-spaced LEPA packages. Some fields may not be suitably level and flat for LEPA, and these LESA systems may be better suited for field conditions.
- If possible, convert one or more wheel line irrigation systems to a linear system equipped with LEPA or LESA in a demonstration program.

- Support UC Cooperative Extension farm audits for agricultural practices and water use efficiency reviews on a farm-scale.
- Support implementation of soil moisture monitoring systems to aid in refining the timing and volume of irrigation water application for all types of irrigation systems
- Support implementation of VFD pump controls to minimize early season over-watering due to higher pumping rates (shallower groundwater levels resulting in less lift)
- Support conversions of pump systems (motors / horsepower reductions) concurrent with LEPA conversions to benefit from lower pressure requirements, for electrical power savings
- Support improvements that can reduce water conveyance losses, including fixing piping leaks and leaks in irrigation system piping
- When possible, promote avoidance of MESA and wheel line irrigation during the highest wind periods
- Conduct community outreach targeted to the farming community to convey information on irrigation efficiency methods, the LEPA Demonstration Program, and opportunities to improve irrigation efficiency and reduce groundwater pumping
- Pursue funding opportunities to implement irrigation efficiency improvements on farms

11. FUNDING AND BUDGET ESTIMATES FOR IRRIGATION EFFICIENCY IMPROVEMENTS IN SIERRA VALEY

The following irrigation efficiency projects and management actions summarized in **Table 11.1** are specific to the GSP Irrigation Efficiency Improvement management action. Preliminary estimated funding requirements and potential implementation timing, subject to funding, is provided. It is hoped that primary funding for this component of GSP implementation can be secured from DWR GSP implementation funding, to the extent made available to Sierra Valley.

As summarized in Table 11.1, to fully implement the irrigation efficiency improvements outlined herein, it is estimated that approximately $1.6 million will be needed for equipment conversions and installations. This does not factor in the costs of like-kind services of the farms for LEPA/LESA equipment installations, and does not cover all the costs to convert to VFD pump control systems. Nor do the estimates account for any significant inflation on costs of equipment and materials. Professional services for implementation are preliminarily estimated at $380,000, and administrative services costs at $100,000. It is envisioned that, subject to funding availability and the anticipation of extensive farmer participation, the irrigation efficiency improvement components could be implemented in years 2023 to 2026.

Other funding opportunities may be pursued, as potentially available from agencies like the US Department of Agriculture (USDA), and other state and federal programs targeted to assist in agricultural improvements, agricultural security, improved water use efficiency, and energy savings. These programs are competitive, and it is difficult to assess to what extent SVGMD or Plumas County might be successful in securing USDA grants, and many grants are only for partial funding, or low-interest loans made to individual farmers.

Table 11.1 – Irrigation Efficiency Improvement Project Component and Preliminary Budget Estimates

Proposed Project / Management Action	Notes	Implementation Years	Preliminary Budget Estimate Equipment	Preliminary Budget Estimate Professional Services	SVGMD and Plumas County Administration
Expand LEPA Demonstration	a) 3 additional center pivot fields, variations of LEPA equipment types, with 2 additional baseline field b) 2 or 3 farm volunteers c) Equipment: 3 LEPA systems installed, 5 flow meters at pivot heads, 5 soils moisture systems	2023-2024	$150,000	$60,000	$10,000
LESA Demonstration	a) 2 additional center pivots, variations of spacing and LESA equipment type, with 1 baseline field b) 1 or 2 volunteer farms c) Equipment: 2 LESA systems, 3 flow meters, 3 soils moisture systems	2023-2024	$80,000	$30,000	$10,000
Wheel Line LEPA Conversion Demonstration	a) 1 wheel line converted to a linear motorized system and converted to LEPA b) 1 volunteer farm	2023-2024	$70,000	$30,000	$10,000
Provide Funding for UC Cooperative Extension to Conduct Farm Audits of Water Use and Irrigation Practices	a) Audit available to all volunteer farms b) Reporting directly to the farm.	2023-2024	$80,000	$10,000	$10,000
Soil Conditioning Demonstration	c) One volunteer farm, implement various soils amendments to improvement water holding capacity d) Farm to provide equipment and manpower	2023-2024	$70,000	$30,000	$10,000

Proposed Project / Management Action	Notes	Implementation Years	Preliminary Budget Estimate Equipment	Preliminary Budget Estimate Professional Services	SVGMD and Plumas County Administration
	e) Equipment: amendment materials compounds, three soils moisture monitoring stations				
LEPA Equipment Fund	a) Make equipment available to all interested farms b) Farm contributes like-kind services for installation c) Sufficient to fund an additional ~40 retrofits of MESA systems to LEPA or LESA, depending on most appropriate system from Demonstration Program	2024-2026	$700,000	$100,000	$30,000
Soil Moisture Implementation Fund	a) Make equipment available to all interested farms, with up to ~15 systems made available, or partial funding for ~40 field installations b) Farm contributes like-kind services for installation	2024-2026	$160,000	$30,000	$10,000
Pump VFD Implementation Fund	a) Make equipment available to all interested farms, with up to ~15 systems made available, or partial funding assistance for up to ~40 wells	2024-2026	$400,000	$100,000	$20,000

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APPENDIX A

LEPA – Sprinkler Head Specs and Data Sheets

LEPA

NELSON

WATER APPLICATION SOLUTIONS FOR CENTER PIVOT IRRIGATION

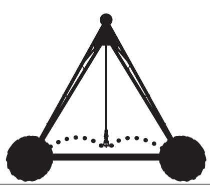
TAN PLATE IN **3030 SERIES**
CONFIGURATION IN BUBBLE-WIDE MODE

LEPA SOLUTIONS

THE TAN BUBBLE-WIDE PLATE IS NOW AVAILABLE FOR LOW ENERGY PRECISION APPLICATIONS IN THE 6-10 PSI RANGE (0.4-0.7 BAR) USING NOZZLE SIZES #9-#50. THIS CONFIGURATION CREATES A WIDER DOME OF WATER THAN STANDARD STRAIGHT DOWN BUBBLERS PROVIDING FULL COVERAGE IRRIGATION. THIS PATTERN TREATS THE SOIL BETTER AND CAN INCREASE EFFICIENCIES BY REDUCING WIND DRIFT AND EVAPORATION VERSUS STANDARD SPRAY PLATES. SPACE FROM 30" TO 60".

D3030 BUBBLE-WIDE PERFORMANCE (DIAM. @ 2' (0.6M))

FOR DROPS



Nozzle #	6 psi (0.4 bar)	10 psi (0.7 bar)
9	6' (1.8 m)	6' (1.8 m)
14	8' (2.4 m)	9' (2.7 m)
24	10' (3.0 m)	11' (3.4 m)
30	12' (3.6 m)	14' (4.3 m)
42	16' (4.9 m)	18' (5.5 m)
50	16' (4.9 m)	20' (6.1 m)

The Nelson Sprayhead can be used in LEPA applications by incorporating the Tan "Bubble-Wide" Plate. Works for both 3030 Series and 3000 Series configurations. LEPA can also be adapted to the Accelerator with the sprinkler converter.

It's important to use LEPA where it fits. While offering the advantages of low pressure operation and minimal water loss due to canopy evaporation and wind drift, LEPA is limited to its areas of application.

Considerations include:

- SOILS.
- The SPEED of the pivot may need to be adjusted to prevent runoff
- Most effective on SLOPES less than 1%.
- You may need to substitute MOVING STREAM sprinklers for inner spans to control over-watering and nozzle plugging.
- PRESSURE REGULATORS are generally a necessity for good uniformity of LEPA nozzle discharge.
- With row crops, PLANTING IN A CIRCLE generally recommended.

3030 Series configuration deposits water directly below the sprinkler without wetting plant canopy.

LEPA - 3030 SERIES
STRAIGHT-DOWN
BUBBLE MODE
(NO SPECIAL PLATE OR CLIP REQUIRED)

LEPA - 3030 SERIES
CONFIGURATION +
SPRINKLER CONVERTER
READY FOR
ACCELERATOR MODE

LEPA - 3000 SERIES
CONFIGURATION

LEPA

Low Energy/Elevation
Precision Application

GERMINATE
IRRIGATE
CHEMIGATE
BUBBLE
DRAG

U3030
+ HOSE
DRAG

BUBBLER
MODE WITH
SPRINKLER
CONVERTER

LEPA (3000 SERIES)

Transform D3000 into LEPA Bubbler by inverting D3000 Cap and attaching Bubbler Clip to the D3000 Body.
(Not to be used with second spray plate.)

HD3000 HOSE
DRAG ADAPTER

Use the 3/4" hose drag adapter on the 3000 Series to apply a hose drag or a drag sock.

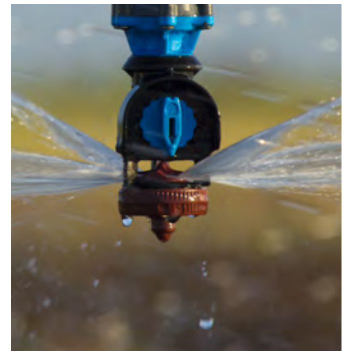
LESA

Low Energy/Elevation
Spray Application

SPRAY
OR
ORBITING
SPRINKLERS

D3030
SPRAYHEAD

SPRAY
MODE WITH
SPRINKLER
CONVERTER



LENA

Low Energy/Elevation
NELSON ADVANTAGE

MOVING
SPRINKLERS:
ROTATOR
ACCELERATOR
SPINNER

A3030
ACCELERATOR

ACCELERATOR
MODE WITH
SPRINKLER
CONVERTER

There is considerable talk about Low Energy/Elevation Solutions for pivots these days. The need to save water and energy is greater than ever. Nelson Irrigation takes this charge seriously and would like to add the NELSON ADVANTAGE to the mix.

Hose drag, bubbler and spray technology qualify as LEPA and LESA so long as the outlet spacings are tight and the devices deliver water at low pressure. Nelson's U3030 can be used for both Part-Circle applications and hose drag applications. The Sprinkler Converter is a great device to get a 3-in-1 sprinkler. Choose between functions: bubble, spray or irrigate with rotating streams depending on water constraints.

Though offering the advantages of low pressure operation and minimal water loss due to canopy evaporation and wind drift, LEPA and LESA applications are limited. Limitations include: tight soils, sloping fields, and inner spans. Due to the very low pressure used, it is necessary to manage the system pressure and monitor it closely. Pressure regulators are generally a necessity for good uniformity of LEPA nozzle discharge.

There are other low energy/elevation options beyond LEPA and LESA. Consider rotating sprinklers in the 6-10 psi (0.4-0.7 bar) range. The Rotator® and Accelerator create a wide wetted pattern for the best soil infiltration and optimal droplet energy.

If you're looking for LE solutions — look to NELSON.

NELSON

NELSON IRRIGATION CORPORATION
848 Airport Rd., Walla Walla, WA 99362 USA
Tel: 509.525.7660 Fax: 509.525.7907 info@nelsonirrigation.com

NELSON IRRIGATION CORPORATION OF AUSTRALIA PTY. LTD.
35 Sudbury Street, Darra QLD 4074 info@nelsonirrigation.com.au
Tel: +61 7 3715 8555 Fax: +61 7 3715 8666

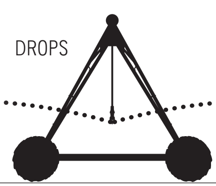
O

NELSON®

WATER APPLICATION SOLUTIONS FOR CENTER PIVOT IRRIGATION

O3030 ORBITOR

FEATURING TECHNOLOGY THAT ELIMINATES THE STRUTS OF A SPRINKLER BODY, NELSON'S PIVOT ORBITOR PROVIDES OUTSTANDING UNIFORMITY AND OPTIMAL DROPLETS AT LOW PRESSURES (6-20 PSI / 0.4-1.4 BAR).



FEATURES & BENEFITS

OUTSTANDING UNIFORMITY AT LOW PRESSURE.
Designed specifically for use on mechanical move irrigation systems — center pivots and linear/lateral machines — the Orbitor delivers a uniform water application pattern.

REDUCED WIND DRIFT AND EVAPORATIVE LOSS.
Strutless sprinkler body design reduces droplet breakup, drift and drool.

COLOR-CODED NOZZLES.
The 3NV Nozzle system is at the center of the 3030 Series Pivot Product line with easy-to-identify, wear-resistant, precision-accurate nozzles. This innovative dial-nozzle combines multiple functions so you can "micro-manage" your system. PRESS, SPIN, CLICK between "on", "off", "flush" and "line flush" funtions.

HEAVY-DUTY RELIABILITY.
Expect long wear life and durability in poor water conditions, because there are no sprinkler body struts for debris to hang up on.

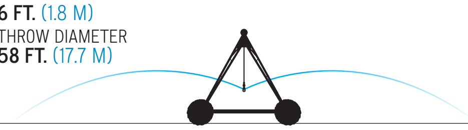
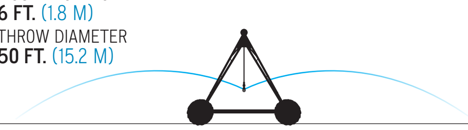
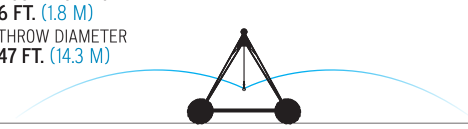
THE NEW PURPLE PLATE DELIVERS A CONSISTENTLY SMALLER DROPLET — IDEAL FOR GERMINATION OF CROPS AND SOILS REQUIRING FINER DROPLETS.

ORBITOR ALSO AVAILABLE IN THE TRADITIONAL 3000 SERIES CONFIGURATION.

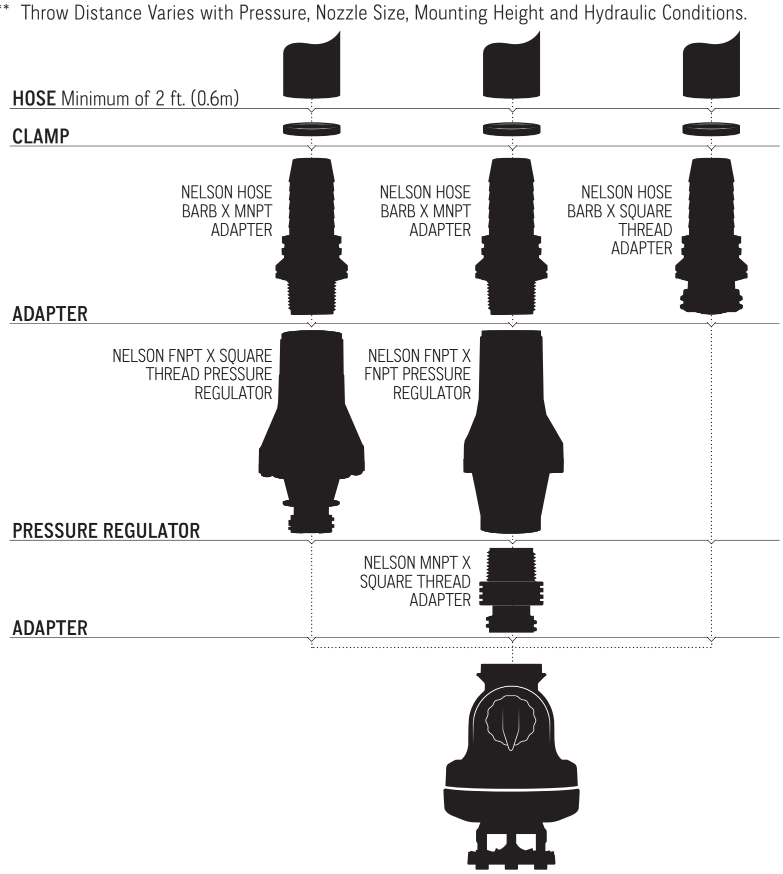
ORBITOR WITH
WEIGHTED COVER

ORBITOR WITH
PLASTIC COVER

PIVOT ORBITOR PERFORMANCE*

		PRESSURE RANGE*	3NV NOZZLE RANGE**	THROW DIAMETER DATA** (no wind tests)
	**BLACK PLATE** **FOR DROP TUBE APPLICATIONS** — Standard Angle — (Use minimum of 2 ft. (.6 m) flex hose)	6-20 PSI (0.4-1.4 BAR)	**#11-50** MINIMUM #16 NOZ. AT 6 PSI (0.4 BAR)	MOUNTING HEIGHT **6 FT.** (1.8 M) THROW DIAMETER **58 FT.** (17.7 M)  COVERAGE @ **15 PSI** (1.0 BAR) **#36 NOZZLE**
	**BLUE PLATE** **FOR DROP TUBE APPLICATIONS** — Low Angle — (Use minimumof 2 ft. (.6 m) flex hose)	6-20 PSI (0.4-1.4 BAR)	**#11-50** MINIMUM #16 NOZ. AT 6 PSI (0.4 BAR)	MOUNTING HEIGHT **6 FT.** (1.8 M) THROW DIAMETER **50 FT.** (15.2 M)  COVERAGE @ **15 PSI** (1.0 BAR) **#36 NOZZLE**
	**PURPLE PLATE** **FOR DROP TUBE APPLICATIONS** — Smaller Droplets — (Use minimum of 2 ft. (.6 m) flex hose)	6-20 PSI (0.4-1.4 BAR)	**#11-50** MINIMUM #16 NOZ. AT 6 PSI (0.4 BAR)	MOUNTING HEIGHT **6 FT.** (1.8 M) THROW DIAMETER **47 FT.** (14.3 M)  COVERAGE @ **15 PSI** (1.0 BAR) **#36 NOZZLE**

* Careful selection of pressure and sprinkler configuration must be taken into account to optimize droplet size.
** Throw Distance Varies with Pressure, Nozzle Size, Mounting Height and Hydraulic Conditions.



IMPORTANT MOUNTING INFORMATION:

1. The Orbitor requires a minimum of 2' (0.6 m) of reinforced flexible hose in the mounting assembly.
2. When using the Orbitor with the weighted cover, do not use any other conventional weight styles instead of, or in addition to, the Orbitor weight.
3. When using the Orbitor with the plastic cover, an inline weight is required. Use Nelson Slim Weights or 3/4" NPT threaded weights. Slip weights require the Nelson Clamp Saver.
4. Always be sure that the Orbitor Weight, Slim Weight, or threaded weight is securely tightened.
5. Always be sure that all components in the mounting assembly and the Orbitor are securely tightened. Use new* Nelson pressure regulators and fittings.
6. If ¾" ball valves are used, use metal nipples or Nelson P/N-12291 plastic nipples.

*New, patented single-strut seat manufactured after 2007.

USE CLAMP SAVER WHEN INSTALLING ORBITORS ON A PIVOT WITH EXISTING POLY SLIP WEIGHTS. This simple device placed over clamps on drop hose beneath poly slip weights protects the clamp from the "action" or natural vibration on Orbitor systems. This is a great solution when an irrigator is retrofitting a pivot that already has slip weights with the Orbitor sprinkler. Only the plastic cover version (6-10 psi / 0.4-0.7 bar) 03000 or 03030 can be used with poly slip weights.

WARRANTY AND DISCLAIMER: Nelson Pivot Orbitor Sprinklers & Pressure Regulators are warranted for one year from date of original sale to be free of defective materials and workmanship when used within the working specifications for which the products were designed and under normal use and service. The manufacturer assumes no responsibility for installation, removal or unauthorized repair of defective parts. The manufacturer's liability under this warranty is limited solely to replacement or repair of defective parts and the manufacturer will not be liable for any crop or other consequential damages resulting from defects or breach of warranty. THIS WARRANTY IS EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING THE WARRANTIES OF MERCHANTABILITY AND FITNESS FOR PARTICULAR PURPOSES AND OF ALL OTHER OBLIGATIONS OR LIABILITIES OF MANUFACTURER. No agent, employee or representative of the manufacturer has authority to waive, alter or add to the provisions of this warranty, nor to make any representations or warranty not contained herein.

This product may be covered by one or more of the following u.s. Patent Nos. 6439477, 7048001, 7140595, 7287710, 7562833, 7942345, 8028932, 9283577 and other u.s. patents pending or corresponding issued or pending foreign patents.

NELSON

NELSON IRRIGATION CORPORATION
848 Airport Rd., Walla Walla, WA 99362 U.S.A.
Tel: 509.525.7660 Fax: 509.525.7907 info@nelsonirrigation.com

NELSON IRRIGATION CORPORATION OF AUSTRALIA PTY. LTD.
35 Sudbury Street, Darra QLD 4074
Tel: +61 7 3715 8555 Fax: +61 7 3715 8666 info@nelsonirrigation.com.au

NELSON IRRIGAÇÃO BRASIL LTDA.
Rua Benedita Mano Schincariol, 110 Santa Cruz, Mogi Mirim, SP 13800-443
Tel: +55 (19) 98816-4992 www.nelsonirrigation.com.br

NELSON

3030 SERIES

With Multi-Function 3NV Nozzle
PRESS, SPIN, CLICK

At the heart of the 3030 Series is the new 3NV Nozzle. Built with the precision accuracy of the 3TN, this innovative dial-nozzle combines multiple functions so you can “micro-manage” your system.

- Quick-change — push & turn, audible “click”
- Stainless steel spring for accurate and secure positioning
- Covers complete nozzle range, using the same numbering and flow rates as the 3TN Nozzle System
- Same color-codes as 3TN but odd-size nozzles have weather-enduring scalloped edge

EVEN NOZZLE

ODD NOZZLE

Important! Do not leave in off position in freezing conditions.

Manage your system without ever having to remove a nozzle.

NELSONIRRIGATION.COM

SQUARE THREAD PRESSURE REGULATOR

SQUARE THREAD X 3/4" ADAPTER

SQUARE THREAD X HOSE BARB

ROTATOR®/SPINNER BODY

ACCELERATOR/ SPRAYHEAD BODY

UNIVERSAL BODY

ORBITOR BODY

The 3NV nozzle fits all existing sprinkler types: Rotator, Spinner, Accelerator, Sprayhead, Orbitor, Part Circle. Maximize efficiency with the Square Thread fitting.

Gain Lots, Give up Nothing.

» SUPERIOR FLUSHING OPTIONS: Sequence to work debris through. It's never advised to stick something in a nozzle – the 3NV flushes with a quick and simple turn of the nozzle. No tools necessary.

» "ON" AND "OFF" CAN BE SELECTIVE: If you're overwatering, or if you need to conserve water for a time, simply select the sprinklers you want to turn off. Consider the cost savings of having a built-in ball valve on every sprinkler!

For new systems ...

SPRINKLER PACKAGE INSTALLATION ENHANCEMENTS

» Maximize efficiency & accuracy — install sprinklers, then walk the line and install nozzles.

» Lugs on end of nozzle are sized & shaped to allow only correct installation and removal.

» Visually identify sprinkler modes for quality assurance.

» Use flush function as needed depending on water quality.

... or seamless integration into existing systems.

COST & TIME SAVING

» To gain the benefits of the new 3030 Series you simply need a new Nozzle & Body. Existing 3000 Series Cap, Plate, Regulator & Fittings integrate entirely.
(NOTE: Orbitor weight can be re-used but need new body/plate.)

» Since On, Off & Flush functions all take place without removing the nozzle, no more dropped or lost nozzles in the field!

» A 3NV Dual Nozzle clip (with Hi-Flo, Lo-Flo differentiation) helps farmers adapt to differing watering needs (such as crop establishment, chemigation or lowering water tables).

NELSON
848 Airport Road, Walla Walla, Washington 99362 U.S.A. / Tel: +1 509.525.7660
Fax: +1 509.525.7907 / info@nelsonirrigation.com / nelsonirrigation.com

APPENDIX B
Soil Moisture Probe Manuals/Instructions

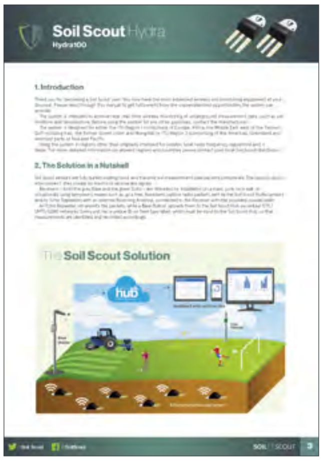
SOIL SCOUT

Soil Scout Hydra User Manual

Hydra100

Contents

1. Introduction .... page 3
2. The Solution in a Nutshell .... page 3
3. Overview and Operation .... page 4
4. Before Installing Devices .... page 5
5. Field Installation of Hydra Sensors .... page 5
6. Troubleshooting .... page 8
7. Technical Specifications .... page 8
8. Compliance Statements .... page 9
9. Disclaimer .... page 9



Soil Scout Oy
Lapinlahdenkatu 16
00180 Helsinki
Finland

sales@soilscout.com
www.soilscout.com

1. Introduction

Thank you for becoming a Soil Scout user! You now have the most advanced wireless soil monitoring equipment at your disposal. Please read through this manual to get full benefit from the unprecedented opportunities the system can provide.

The system is intended to achieve near real-time wireless monitoring of underground measurement data, such as soil moisture and temperature. Before using the system for any other purposes, contact the manufacturer.

The system is designed for either the ITU Region 1 (comprising of Europe, Africa, the Middle East west of the Persian Gulf including Iraq, the former Soviet Union and Mongolia) or ITU Region 2 (comprising of the Americas, Greenland and selected parts of Asia and Pacific.

Using the system in regions other than originally intended for violates local radio frequency regulations and is illegal. For more detailed information on allowed regions and countries please contact your local Soil Scout distributor.

2. The Solution in a Nutshell

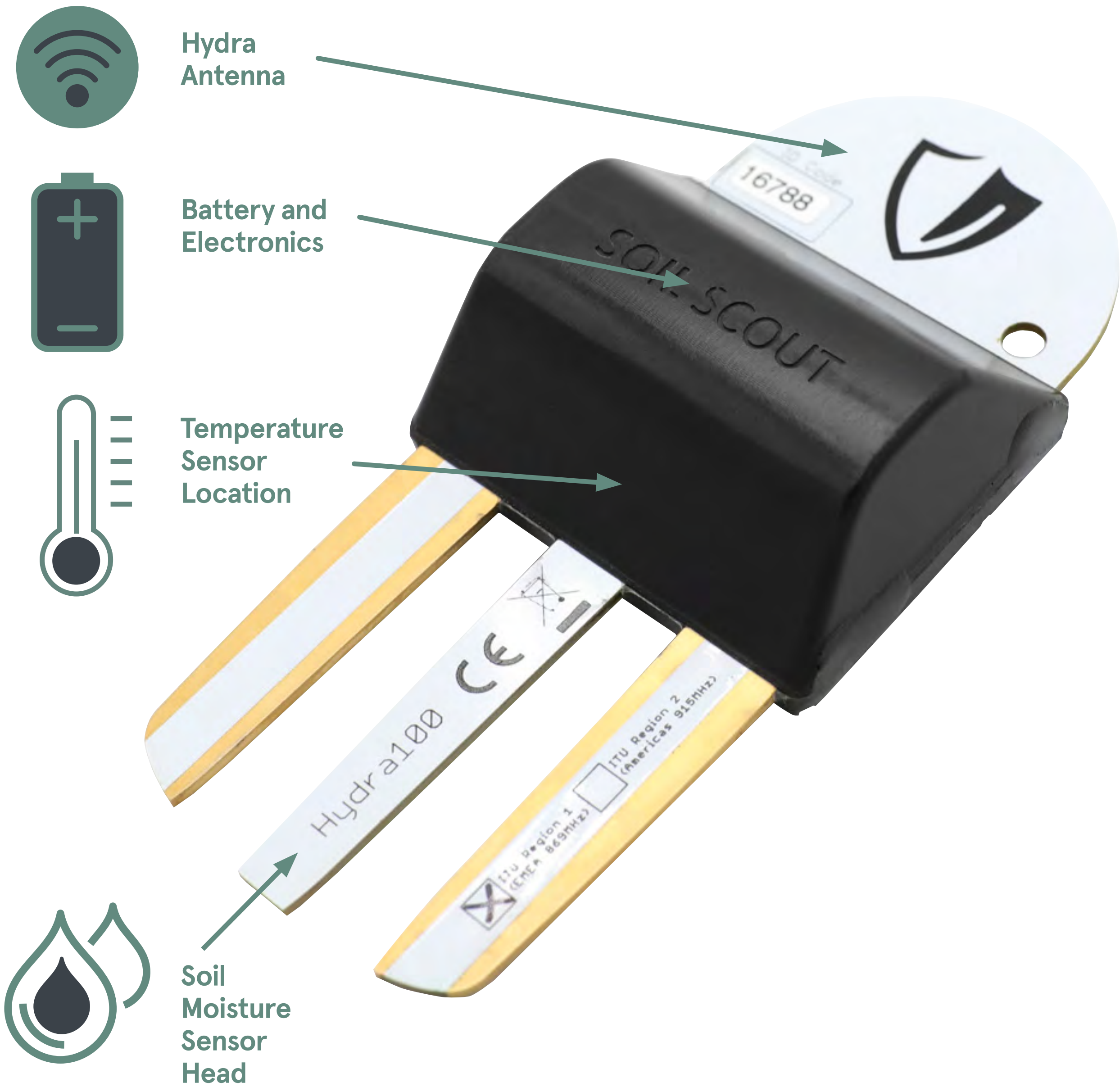
Soil Scout sensors are fully buried underground and transmit soil measurement data packets periodically. The sensors do not interconnect, they create no mesh nor receive any signals.

Receivers - both the grey Base and the green Echo - are intended for installation on a mast, pole, on a wall, or occasionally using temporary means such as up a tree. Receivers capture radio packets sent by the Soil Scout Hydra sensors and/or Echo Repeaters with an external Receiving Antenna, connected to the Receiver with the provided coaxial cable.

An Echo Repeater retransmits the packets, while a Base Station uploads them to the Soil Scout Hub via cellular (LTE/UMTS/GSM) networks. Every unit has a unique ID on their type label, which must be input to the Soil Scout Hub, so that measurements are identified and recorded accordingly.

3. Overview and Operation

The Soil Scout Hydra100 device, depicted below, is intended for underground installation, while the Gateway for receiving the data transmitted from underground is intended for installation above-ground and in air. Each sensor unit has a unique ID on a sticker on the front face, which is used to distinguish the data source in the Soil Scout Hub.

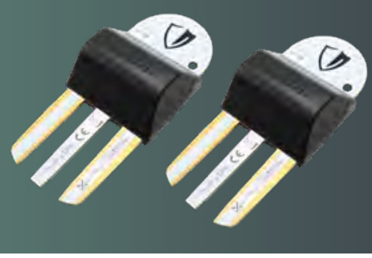


The Hydra has an embedded antenna, battery, electronics and sensors. The antenna is in the semi-circular end, while the soil sensor head is the set of three prongs in the other end. The battery and electronics are molded inside the plastic center and cannot be replaced or accessed in any way.

Hydra sensors have a preset interval to perform measurements and transmit the results, typically every 20 minutes. There are other variants available, and the preset interval cannot be adjusted after production.

The device is permanently sealed in manufacturing and is fully waterproof to allow installation in completely water-filled environments, where no hazardous chemicals such as solvents are present.

The radio transmitter of the Hydra produces the maximum allowed radio power of 27 dBm (500 mW) according to European radio regulations (Directive 1999/5/EC). Any attempts to enhance the transmission power by self-made means will cause prohibited emissions and are therefore strictly forbidden.



4. Before Installing Devices

All Soil Scout devices are ready for use when delivered. The Hydra transmitters have been tested and put into operation in manufacturing and there is no way to adjust their operation.

However, it is good practice to perform certain procedures before mounting receiving equipment or burying Hydra transmitters. This way device setup can be verified with the least effort before going out in the field. Set up your site in the Soil Scout Hub as outlined in the Hub Manual. Power up your Base Station and check that it reports to the online Hub properly – detailed instructions for this can be found in the Receivers Manual.

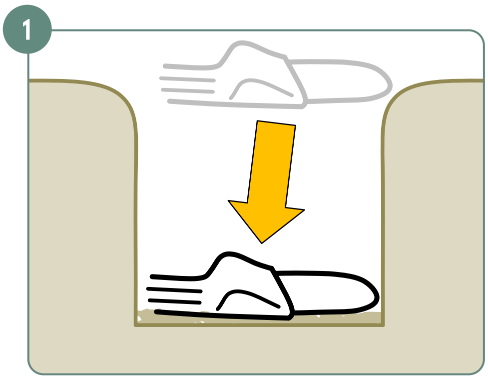
Keep the Hydra sensors in near vicinity to the Base Station for an hour and check all scouts report data to the Cloud. Once they do, you can be sure everything will work out in the field as well.

Make a plan of your sensor deployment before going out. It is easier and more reliable to execute a good plan and write down eventual changes to it, than simultaneously carry out the field work and document it. A good plan covers following:

- Map of intended locations where each Hydra goes
- Hydra ID numbers on the map
- Intended depths of each Hydra
- Means to write down soil observations during installation
- Positioning device or other means to exactly record the realized locations

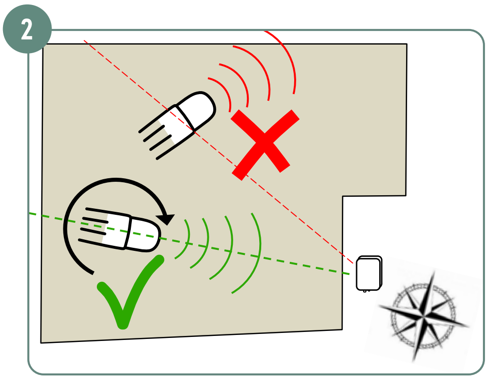
Keep a copy of your plan in office and make a backup of a modified plan after the field work. Remember, that after deployment there are no means to resolve an individual Scout Hydra's location. The transmissions are very short, occur seldom and often have powers below noise floor, so feasible technical methods to triangulate devices do not exist to date.

5. Field Installation of Hydra Sensors



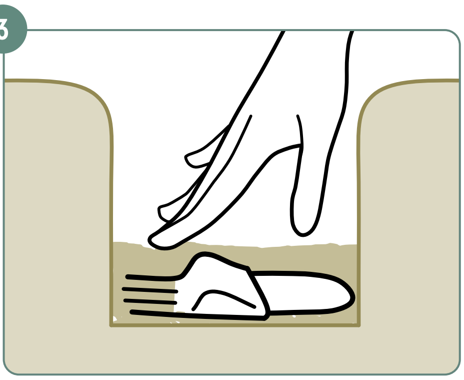
- Dig an installation hole to the desired installation depth only. Digging too deep will disturb the bottom soil.
- Leave approx. 1 cm (0.4") of loose soil on the bottom of the pit to allow for firm soil contact with the device.
- Place the device on the pit bottom. Place only one Scout in one pit.

Note: *Before installation, write down the 5-digit Hydra ID code for each unit you are burying. During installation, record exact depth and precise*



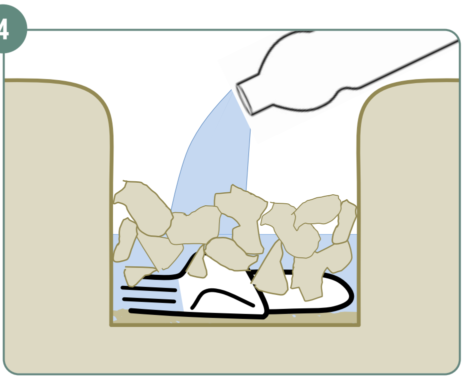
- Ensure that the round end (the antenna) of the Hydra sensor is pointing towards your desired receiving antenna (Base Station or Echo Repeater).
- Installing the Hydra sideways will ruin communication range distance.
- Choose the locations for your devices so that the line of sight from Scout to the Receiver is open and free of obstacles.

3



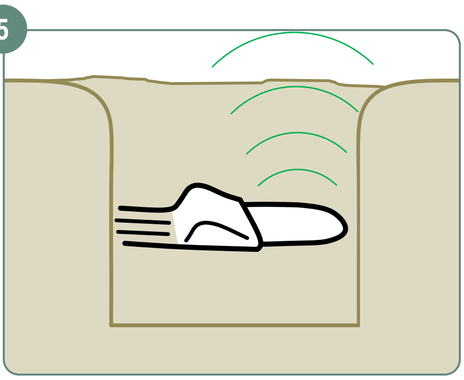
- Stuff soil firmly all around the sensor by hand. Give the device a tight soil contact and leave no air pockets.
- Do not use tools or hard objects as accidental impacts on the device may damage it.

4



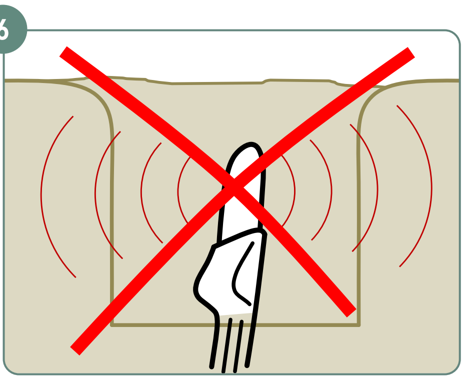
- If the soil is so hard or dry that it breaks into blocks or clumps, apply lots of water and knead the soil to make it softer. The sensor will initially give unrepresentatively high moisture readings, but the surrounding soil will absorb the excessive moisture in a few days.

5



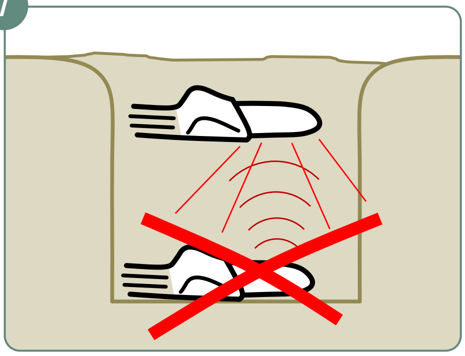
- Replace all of the removed soil back into the installation pit. Preserving the original order of soil layers, if possible, is recommended.
- Pile any extra soil into a mound on top of the pit. Do not leave a depression on the surface, as it will collect excessive surface water and may affect moisture measurements in the future.

6



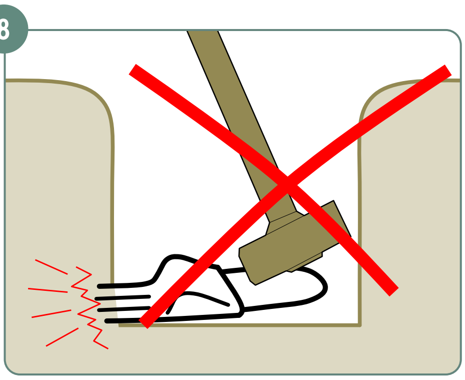
- Do not place the Scout in an upright position. The radio signal would be unable to get up in the air and the the sensor will not communicate.

7



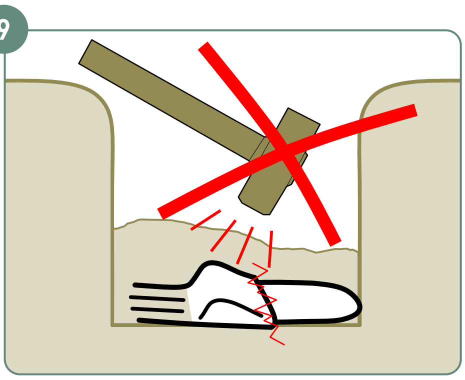
- Do not place multiple Scouts in one pit. The top one will block radio transmissions from deeper ones. Give each Scout its own pit and keep the pits at least 0.6m (2 feet) apart.

8



- Do not use tools to compact the soil. Once the sensor is well covered, it's OK to step on the soil to compact it to the original compaction level.

9



- If you choose to push the sensing head pins into the undisturbed soil wall, be absolutely sure to have the sensor flat and firm on the bottom of the pit. Any loose soil beneath the sensor will compact back over time, causing a high risk of breaking the sensing head pins.
- If the soil is too hard to penetrate gently pushing by fingers, use a pocket knife or similar tool to make the opening before pushing. Bear in mind, that the warranty will not cover for mechanically broken sensors.

A few good practices on how to set up a larger monitoring site instrumentation step by step:

✔ Begin by installing sensors close to a Receiver and make sure they communicate before working your way further out.
✔ In case you want to bury a sensor exceptionally deep, place the deepest ones nearby a Receiver to balance the depth and distance attenuations.
✔ Install Scouts in sessions, if possible, and observe the performance before you continue.
✔ If the most distant sensors don't connect when buried, resolve whether you can elevate the Receiving Antenna or obtain a directive one.
✔ When you have reached the limit of reception range, put up an Echo Repeater and continue the process.

6. Troubleshooting

No data coming in from a Hydra Scout, right after installation
The standard Hydra Scouts report once per twenty minutes. A single packet can be lost by chance, but if several packets regularly go missing, the Scout is either too deep or too far or both. Bring the unit closer or install an Echo Repeater to cover that location.

No data coming in from a Hydra Scout, after initially working
If the Scout has been at the very edge of reception, changing conditions can render the received signal strength too low to be picked up. Such changes are increased moisture levels, increased salinity in the soil, growing plants and other objects in the radio path. Bring the unit closer or install an Echo Repeater to cover that location.

Moisture reading is very low after installation
The sensor needs to be properly in contact with the soil. This can best be achieved by working a part of the soil around the Scout with water into a moist paste and stuffing the paste tightly around the sensor.

Moisture reading doesn't change during heavy watering event (rain or irrigation cycle)
Percolation speed through the soil is largely dependent on soil type, installation depth and the crop growing. If the readings don't change, chances are that it's because the conditions at sensor level don't change - meaning that the sensor is actually working correctly. If you want to make sure the sensor reacts to water, place it in a glass of water and see the reading go to typically above 60% (it won't go 100% even when fully immersed since the sensor value is calculated for soil with water, not water without soil).

7. Technical Specifications

Specifications subject to change without notice
For additional information, please contact the Soil Scout team at: **info@soilscout.com**

Hydra100 Scout

Radio power	27.0 dBm (500 mW) ERP, Bandwidth <250 kHz, duty cycle <0,001%.			
Frequency Variants	869.525 MHz (ITU-1) Europe & selected other markets 921.700 MHz (ITU-2) Americas, Australia, NZ & selected other markets 920-925 MHz (FHSS) Hong Kong, China Custom Information upon request			
Battery Capacity	3000 mAh, encapsulated primary lithium			
Life expectancy	Up to 20 years @ 1 cycle per 20 minutes			
Encapsulation	Black polyurethane molding			
Dimensions (LxWxH)	129 × 59 × 25 mm (5.1" × 2.3" × 1.0")			
Sensors	Temperature 3-prong integrated Capacitive (moisture content) & Resistive (EC / salinity)			
Moisture Accuracy	± 2 % mean error (1 % with correct soil type, 1 % installation repeatability)			
EC Accuracy	± 0.2 dS/m mean error, Typical resolution 0.1 dS/m, Range 0 to 20 dS/m			
Dielectric Accuracy	± 2 % mean error, Resolution 0.5 to 1.5 Є, Range 1 to 135 Є			
Temperature Accuracy	Range -40 to +80 °C / -40 to +176 °F		Accuracy: +/- 0.1 °C / 0.18 °F	
Resolution	-40 to -11 °C -10 to +10 °C +10.5 to +80 °C	1.00 °C 0.25 °C 0.50 °C	-40 to +12 °F -12 to +50 °F +51 to +176 °F	1.80 °F 0.45 °F 0.90 °F

8. Compliance Statements

Soil Scout ltd. / Soil Scout Oy hereby declares that Soil Scout Hydra 100 is in compliance with the following requirements:

- **RoHS Directive** (2011/65/EU)
- **WEEE Directive** (2012/19/EU)
- **Battery Directive** (2006/66/EC)
- **RED Directive** (2014/53/EU)
- **EMC Directive** (2014/30/EU)
- **Low Voltage Directive** (2014/35/EU)
- **ErP Directive** (2009/125/EC)

Please dispose this product by taking it to your local collection point or recycling center.

This will help to protect the environment in which we all live.

FCC compliance: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Changes or modifications not expressly approved by Soil Scout ltd. could void the user's authority to operate the equipment.

9. Disclaimer

Soil Scout ltd. / Soil Scout Oy disclaims any and all liabilities related to or arising from third parties' products or services, which use the data generated by a Soil Scout product. Soil Scout ltd. / Soil Scout Oy disclaims any and all liabilities related to or arising from the functioning / malfunctioning of third party product or service, its interoperability with a Soil Scout product, safety of a third party product or service as well as any other liabilities related to or arising from a third party product or service. Soil Scout ltd. / Soil Scout Oy shall not be liable for any data transfer fees or any other fees which might be due to or related to the use of Soil Scout products.

These products are protected by patent pending.

How to find out more

For more information on the Soil Scout solution and to request all relevant pricing options please contact the Soil Scout sales team via email or your nearest reseller.

sales@soilscout.com

Soil Scout Oy
Lapinlahdenkatu 16
00180 Helsinki
Finland

www.soilscout.com

@Soil_Scout @SoilScout

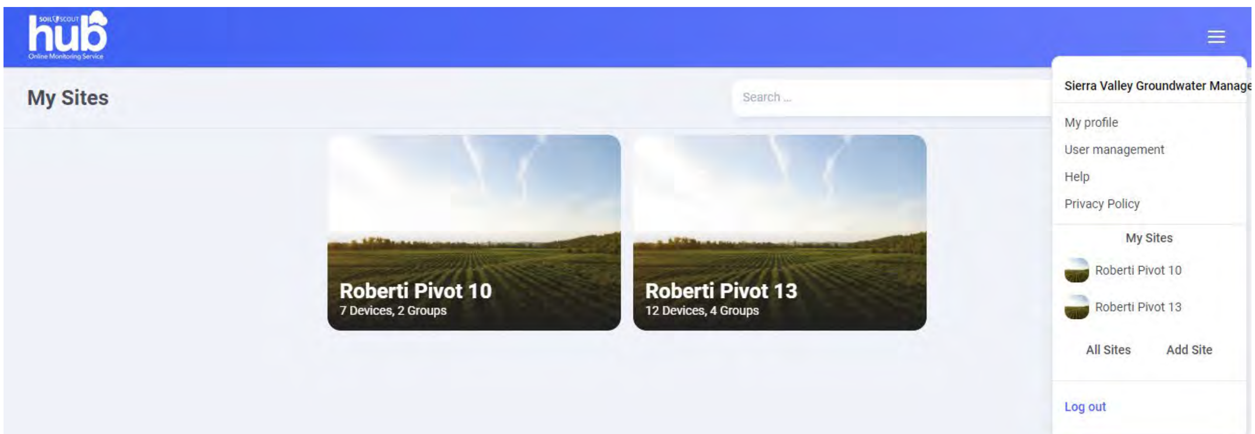
#GAINADEEPERVIEW

SOIL SCOUT Website and Data Download Guide Basics

For access to soil moisture data at both the Pivot 10 and Pivot 13 sites, the website houses the data. Data from the sensors is uploaded every 55 minutes on Roberti Pivot 13, and data is updated every 20 minutes from the sensors on Roberti Pivot 10.

https://soilscouts.fi/sites
Login ID: SVGMD
Password: svgmd123
Email associated with account: sierravalleygmd@sbcglobal.net

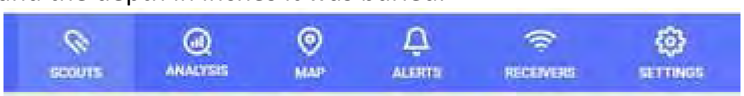
You can add separate users or change your password, or you can continue to use the above information. The three lines in the upper right side of the website will give access to account settings.



Upon login, you'll see there are the two separate pivots. If you chose one, it will bring you to all the soil moisture sensors for that pivot field. You can select individual moisture sensors to see the data for just that sensor or stay on that first page where it shows the aggregate of all the pivot's sensors. You can change the date range by clicking the Last 6 months button in the upper-right to set the dates.

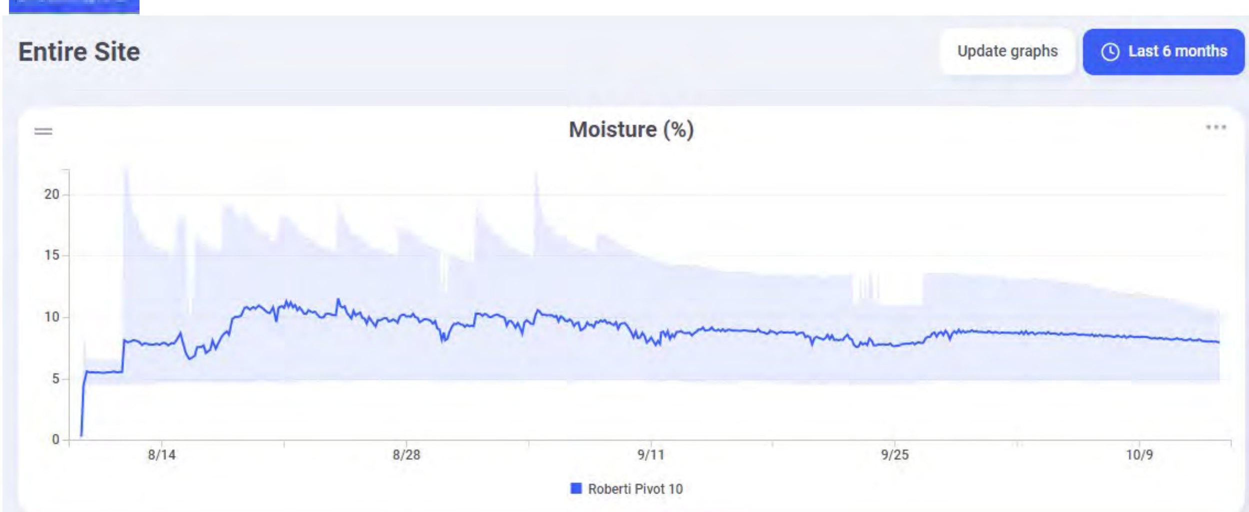
Website and Data Download Guide Basics

The soil moisture names are based on approximate distance to the antenna on the outside of the field, and the depth in inches it was buried.

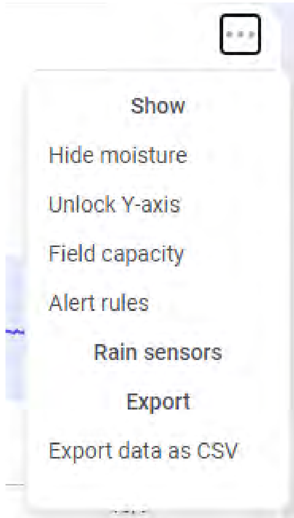


If you click on the "Map" on the top of the page, it will show where the sensors are located on the field in satellite imagery.

To switch between the two pivot sites, click the "Hub" in the upper-left corner.



Website and Data Download Guide Basics



Downloading data to .csv files for all the sensor data at the site can be done by clicking on the three dots on the upper right side of the graph. Which will have the options pop up, click "export data as csv" and a .csv file will automatically start downloading with all the sensors moisture, temperature, salinity and water balance data. The .csv file can be resaved as an excel file for further formatting and editing.

Primary contacts for help at Soil Scout are:
Jason VanBuskirk (east coast) jvb@greensightag.com Sales and General
Kevin Hauschel (west coast?) khauschel@greensightag.com More field/technical

More User Guides/ Manuals for Soil Scout can be found at:

https://soilscout.com/user-guides

APPENDIX C
Flow Meter Manual/Instructions for Data Download

AG3000

Irrigation Magmeter Instructions

Seametrics

Your first replacement battery is on us. Just call!

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Seametrics Limited Warranty .... Back

Note: These instructions cover the AG3000. For details on the AG3000p or AG3000r, see the *AG3000p & AG3000r Irrigation Magmeter Instructions*.

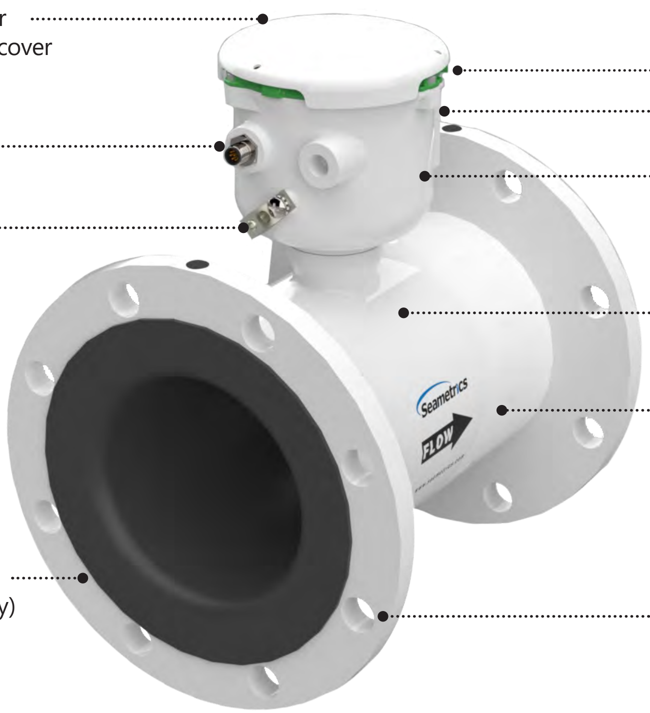
The **AG3000 Series** is a spool-type electromagnetic flowmeter for use in irrigation applications in 2” to 12” pipe. With no moving parts, these meters provide unobstructed flow and are resistant to wear from debris found in ground or surface water. Little maintenance is required because there are no bearings to wear out or propellers to stop turning. Minimal straight pipe requirements allow AG3000 meters to be used in piping configurations where there is little space between the meter and an elbow.

The standard AG3000 is battery powered with an available pulse output. Both rate and total indication show on the meter mounted display. Bidirectional flow reading is standard with totals available in forward, reverse, net flow, batch forward flow, and batch reverse flow. Built-in data logging is available as an option for secure flow logging.

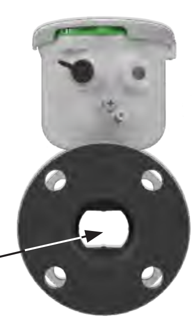
The AG3000 is also available with external DC power. With an externally powered AG3000 an additional output can be added, such as 4-20mA, or Modbus®. The battery powered model is available with Modbus® but will shorten battery life.

The AG3000 Series is CE certified and rated IP68 for burial, or applications where the meter may be under water for prolonged periods of time. All meters are provided with a security seal to protect against unauthorized access. The seal can be broken by an authorized agent to replace the battery pack. The cable is field installed where external power is available and/or an output is needed.

Features



AG3000



Free battery replacement at year five with warranty registration!

Specifications*

Pipe Sizes		2", 3", 4", 6", 8", 10", 12"
Flanges		150 lb. ANSI Pattern
Pressure		150 psi (10.3 bar) line pressure
Temperature	**Operating**	10° to 140° F (-12° to 60° C)
	Storage	-40° to 158° F (-40° to 70° C)
Accuracy		±0.75% of reading on AG3000p and AG3000r (±1.0% AG3000), ±0.025% of full-scale flow from low flow cutoff to maximum flow rate of 10 m/sec
Low Flow Cutoff		0.5% of maximum flow rate
Material	**Body** *(2"-12")*	Welded steel, epoxy-coated
	Liner *(2" & 3")*	Polyurethane/Noryl®
	Liner *(4"-12")*	Santoprene flange/Polypropylene liner body
	Electronics Housing	Powder-coated diecast aluminum
	Electrodes	316 stainless steel
Display	**Type**	128x64 dot-matrix LCD
	Digits	5 Digit Rate; 8 Digit Total
	Units *Please Note: All AG3000 meters are factory set for gallons per minute (GPM) rate and acre feet total. If other units are required, they can be set in the field.*	Rate Volume Units: Gallons, Liters, Barrels(42 gal), Cubic Feet, Cubic Meters, Million Gallons[2], Mega Liters[2], Imperial Gallons, Million Imperial Gallons[2] Rate Time Units: Second, Minute, Hour, Day Total Volume Units: Gallons, Gallons x 10, Gallons x 100, Gallons x 1000, Million Gallons, Liters, Kilo Liters, Mega Liters, Barrels (42 gal), Cubic Meters, Cubic Meters x 1000, Cubic Feet, Cubic Feet x 100, Cubic Feet x 1000, Second Foot Day, Million Cubic Feet, Acre Feet, Acre Inches, Imperial Gallons, Imperial Gallons x 1000, Million Imperial Gallons, Fluid Ounces
	Bidirectional[1]	Forward Total, Reverse Total, Net Total, Batch Forward Total, Batch Reverse Total [3]
Power	**DC Power**	9-36 Vdc @ 250 mA max, 30 mA average
	Battery Backup **(Not for use as primary power)**	DC powered units: One lithium 7.2V 'D' size battery pack, replaceable. AC powered units: One 9V alkaline battery, replaceable.
	AC Power	85-264Vac, 50/60Hz, 0.12A *(AG3000p and AG3000r only)*
	Battery	One lithium 7.2V 'D' size battery pack, replaceable. *(AG3000 only)*
Scaled Pulse Output	**Signal**	Current sinking pulse, isolated, 36 Vdc at 10 mA max
	Pulse Rates	User-scalable from 0.1 to 99,999.9 volume units/pulse. Pulse width is one-half of pulse period with minimum pulse width of 2.5 ms, 200 pulses/sec max. For battery option meters, pulse width varies with frequency, 150 pulses/sec max.
Options	**4-20mA Current Loop**	Isolated, passive, 24Vdc, 650 Ω maximum current loop
	High Speed Digital	Isolated, open collector, 24 Vdc *(AG3000p only)*
	Serial Communications	Isolated, asynchronous serial RS485, Modbus® RTU protocol
Cable	**Power/Output Cable**	20ft (6m) standard length polyurethane jacketed cable—for power and outputs (lengths up to 200' available).
	Remote Display Cable	20ft (6m) standard length polyurethane jacketed cable—for connection between meter and remote display (lengths up to 200' available). *(iMAG 4700r)*
Conductivity		>20 microSiemens/cm
Empty Pipe Detection		Hardware/software, conductivity-based
Regulatory		CE (EN 61326)
Environmental		NEMA 6P, IP68 (10ft (3m) depth, continuously)

Modbus® is a registered trademark of Schneider Electric.

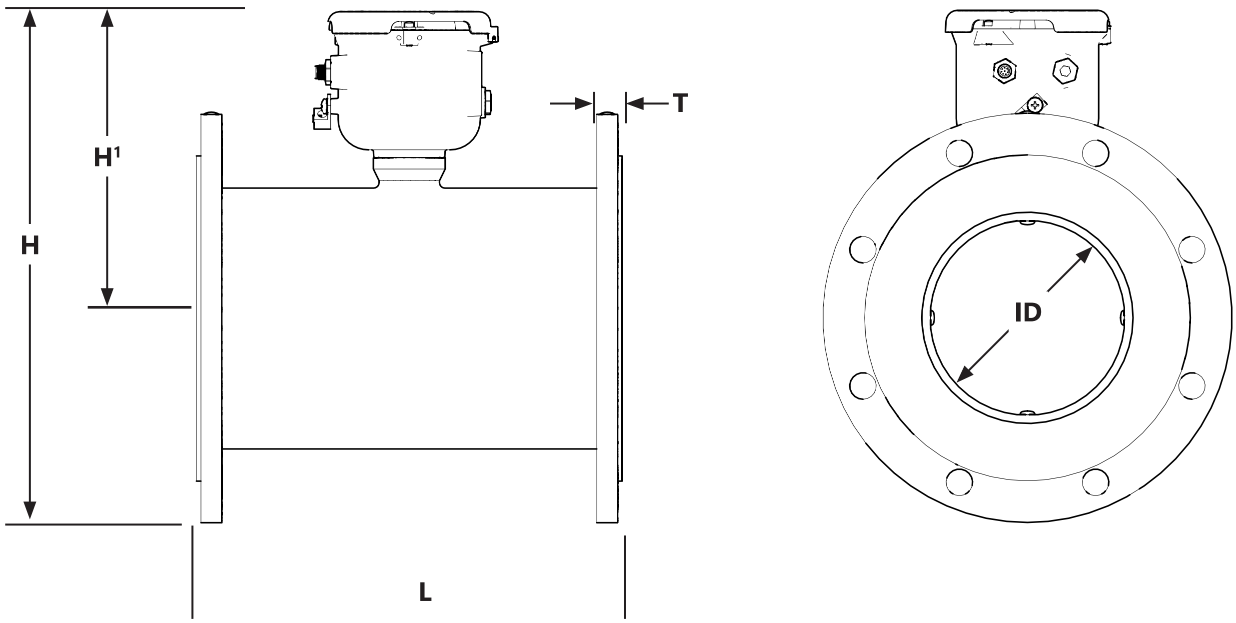
* *Specifications subject to change. Please consult our website for the most current data (www.seametrics.com).*

1 *If forward and reverse flow data needs to be sent to another device, either the Digital or Modbus® output is required.*

2 *Rate Time Unit is available in Day only.*

3 *Forward and reverse flow totals are non-resettable. Batch forward and batch reverse totals can be reset.*

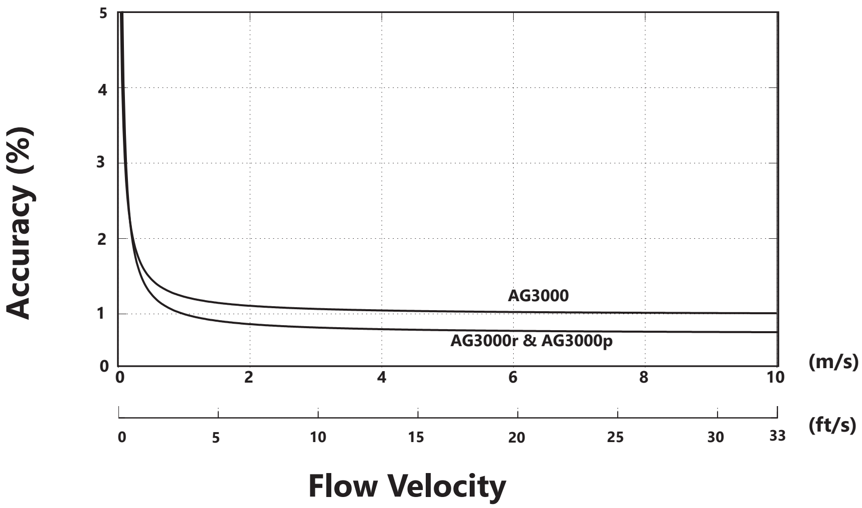
Dimensions



AG3000 Meter Size	L		H1		H		T		ID		Bolt Holes	Shipping Weight	
	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm	#	lbs	Kg
2"	7.9	200	7.58	193	10.58	268.73	.62	15.7	1.76*	45*	4	20	9
3"	7.9	200	8.08	206	11.83	300.48	.62	15.7	2.68*	68*	4	26	11.8
4"	10.12	257	8.33	211	12.83	325.88	.62	15.7	3.12	79	8	33	15
6"	12.09	307	9.14	231	14.64	371.86	.69	17.5	5.05	128	8	49	22
8"	14.14	359	10.14	257	16.89	429.01	.69	17.5	6.44	164	8	70	32
10"	18.08	459	11.2	284	19.2	487.68	.69	17.5	8.61	219	12	130	59
12"	19.68	500	12.2	310	21.7	551.18	.81	20.6	10.55	268	12	170	77
Flanges	Standard ANSI 150 lb. drilling											Cable 1 lb.	

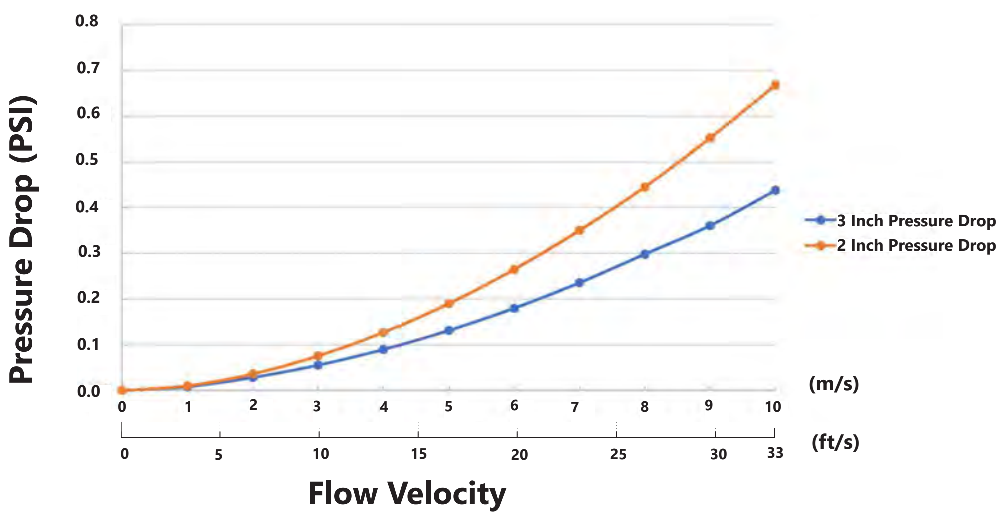
Note: 'L' dimension is total from liner face to liner face
*Average ID

AG3000 Accuracy



2” & 3” Pressure Drop

Note: No pressure drop in 4”-12” meters



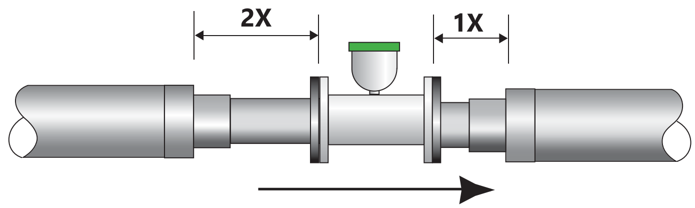
Flow Rate (2” - 12”)

Pipe Size *(Inches in diameter)*	2”	3”	4”	6”	8”	10”	12”
Max Flow Rate *(Gallons/Minute)*	321	722	1285	2891	5140	8031	11565
Cut-off (min) Flow Rate *(Gallons/Minute)*	1.61	3.61	6.43	14.46	25.70	40.15	57.82
Max Flow Rate *(Liters/Second)*	20.25	46	81	182	324	507	730
Cut-off (min) Flow Rate *(Liters/Second)*	0.13	0.23	0.41	0.91	1.62	2.54	3.65
Max Flow Velocity *(Meters/Second)*	10	10	10	10	10	10	10

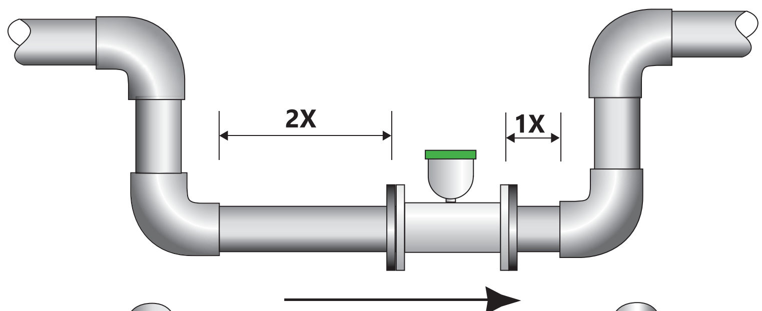
Straight Pipe Recommendations (X = diameter)

NOTE: These configurations are to be used as general guidelines and do not cover every possible installation. A combination of two or more obstructions will require additional straight pipe. If there is any concern about the length of pipe required for a specific application, please contact your local dealer.

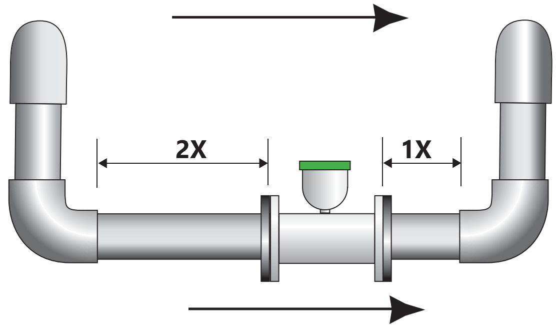
Reduced Pipe



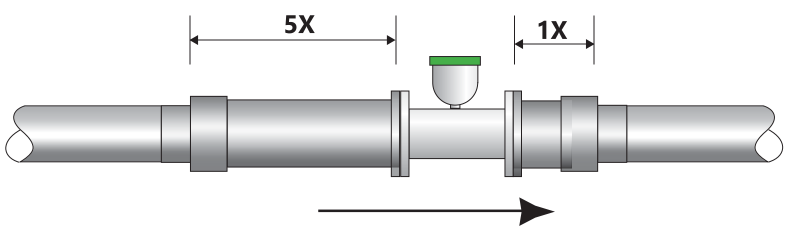
Two Elbows In Plane



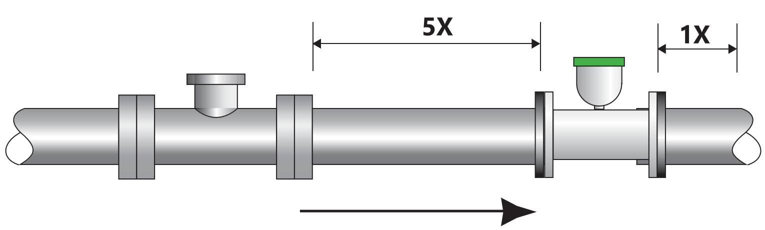
Two Elbows, Out Of Plane



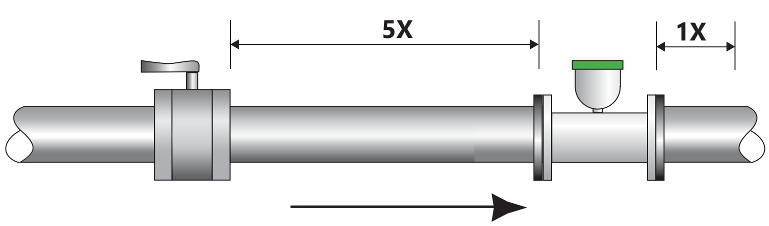
Expanded Pipe



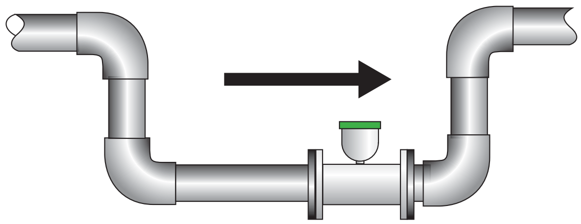
Swirling Flow:
Propeller Meter



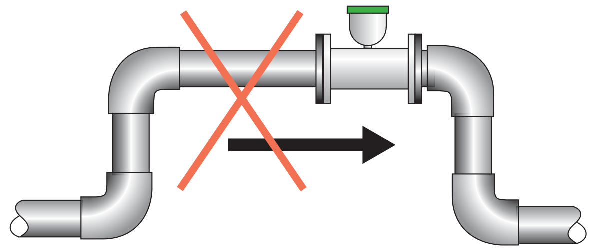
Swirling Flow:
Partially Open
Butterfly Valve



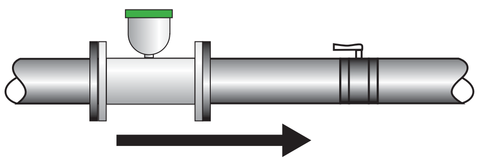
Full Pipe Recommendations



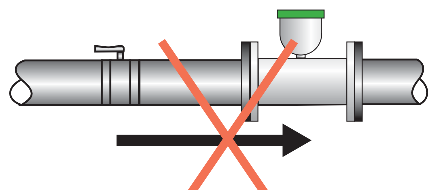
Recommended:
Keep pipe full at meter for accuracy



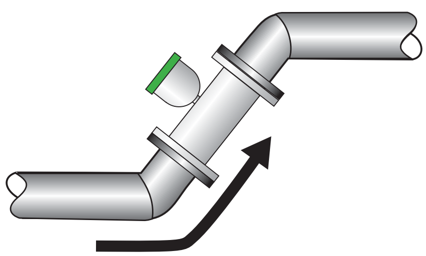
Not Ideal:
Allows air pockets to form at meter



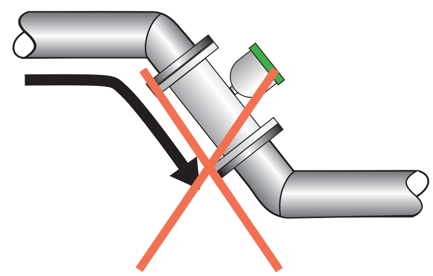
Recommended:
Keeps pipe full at meter for accuracy



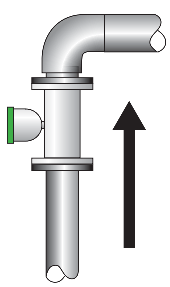
Not Ideal:
Post-valve cavitation can create air pocket



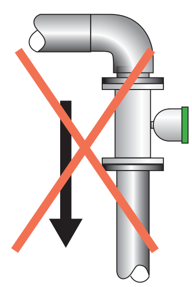
Recommended:
Allows air to bleed off



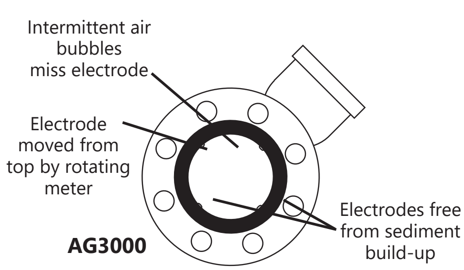
Not Ideal:
Air can be trapped



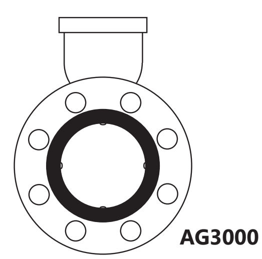
Recommended:
Allows air to bleed off



Not Ideal:
Air can be trapped



Best:
Improved accuracy results from unimpeded electrodes



Not Ideal:
If pipe contains air bubbles or sediment (may affect accuracy)

Positioning the Meter

CAUTION: **These flow sensors are not recommended where installation may exceed a maximum recommended operating temperature of 140˚ F.**

These meters can be installed horizontally, vertically (with upward flow), or in any radial position.

The meter must not be installed where it will be exposed to extreme levels of vibration.

Using a check valve on the upstream side of the meter, and/or an air vent (vacuum relief valve) in the same, unobstructed run of pipe as the meter, is required in any installation where the meter may be exposed to suction when the system is not in normal operation. Suction can cause damage to the liner. Liner damage caused by suction, without the use of a check valve and/or air vent, may void the warranty.

Straight Pipe Recommendations. The AG3000 requires straight pipe before and after the meter for best accuracy. However, the ability of electromagnetic meters to average the flow across the entire pipe allows for shorter straight pipe recommendations than most mechanical meters (see page 7).

Full Pipe Recommendations. To prevent false readings, this meter is designed to indicate 'EMPTY PIPE' if one or more electrodes is exposed. For highest accuracy, install the meter so that the pipe will be full when there is flow. If air bubbles may be present in the pipe or sludge accumulation is an issue, rotate the meter by one flange hole to position the control housing at a 45˚ angle (see diagrams on page 8).

Fittings. The AG3000 has ANSI 150 lb. drilled flanges and will mate with any other ANSI 150 lb. flanges. *See table on page 10 for flange bolt tightening torque specifications.*

Calibration. The AG3000 is factory-calibrated before shipping. The frequency of recalibration will depend on the needs of each application and local regulatory policies.

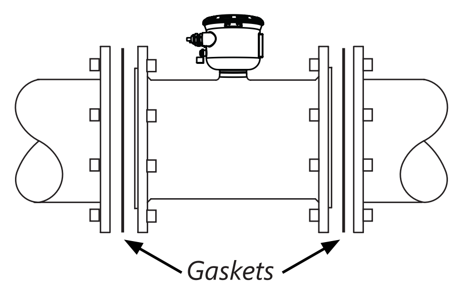
Chemical Injection. When the AG3000 is used in a chemical injection application, **the chemical injection point must be placed downstream of the magmeter OR far enough upstream for complete mixing to occur before the fluid reaches the meter.** When unmixed chemical alternates with water passing through the meter, the rapid changes in conductivity may cause sudden spikes and drops in the meter's reading, resulting in inaccurate measurement. The magmeter will re-stabilize, however, with a steady flow of fluid of uniform conductivity.

CAUTION: In chemical injection applications, install chemical injection point downstream of magmeter, or far enough upstream to allow complete mixing of fluids.

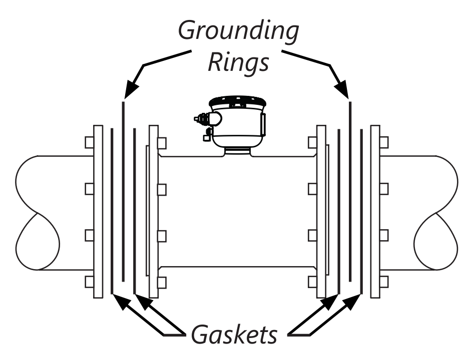
Installing Gaskets

GASKETS
Gaskets are required at all junctions.

1. Be sure all mating surfaces are smooth and free of debris.
2. Install Seametrics provided gaskets, or equivalent, on each end of meter as shown in diagrams below. If using grounding rings, install one gasket on each side of the grounding ring.
3. **Failure to install gaskets will void warranty.**



Installation <u>without</u> grounding rings

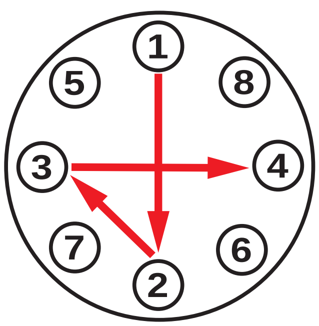


Installation <u>with</u> grounding rings

Tightening Flange Bolts

NOTE: Mating pipe flanges must be ANSI 150# full face (FF) and/or raised face (RT).

1. Tighten flange bolts in an alternating pattern.
   - Tighten left flange bolt-1 to 20% recommended torque.
   - Tighten right flange bolt-1 to 20% of recommended torque.
   - Repeat steps a and b for each bolt in an alternating order, such as shown at right, tightening to 40%, then 60%, then 80%, and then 100%.
2. Test for leaks.
3. If needed, tighten further in 10% increments until leaking stops. **DO NOT over-tighten. Over-tightening can cause serious damage to the flow meter.**
4. Recheck after 24 hours, adjusting if needed.



Suggested Tightening Sequence

Caution: **Improper tightening sequence can cause serious damage to the flow meter.**
- **Do not tighten one side at a time.**
- **Do not tighten each bolt completely at one time.**

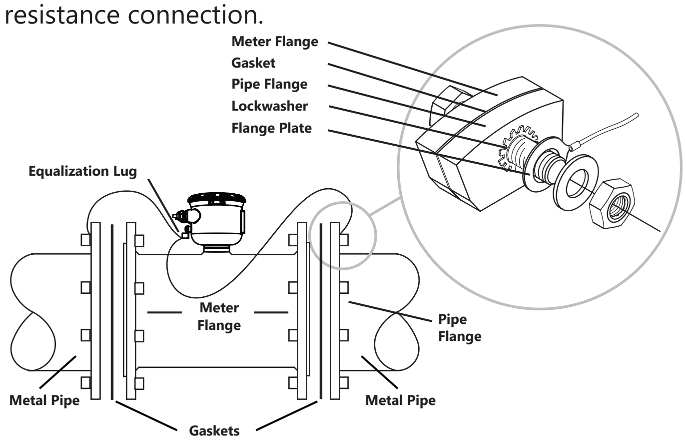
SUGGESTED FLANGE BOLT TORQUE

Pipe Size	Liner	
	ft-lb	Nm
2″	18	25
3″	25	34
4″	20	27
6″	42	57
8″	65	88
10″	73	99
12″	97	132

Equalization and Grounding

WARNING: ELECTRICAL SHOCK HAZARD
When the AG3000 is installed in a plastic piping system, or when externally powered, the piping system must be grounded to meet national and local electrical safety codes. Failure to do so can result in electrocution.

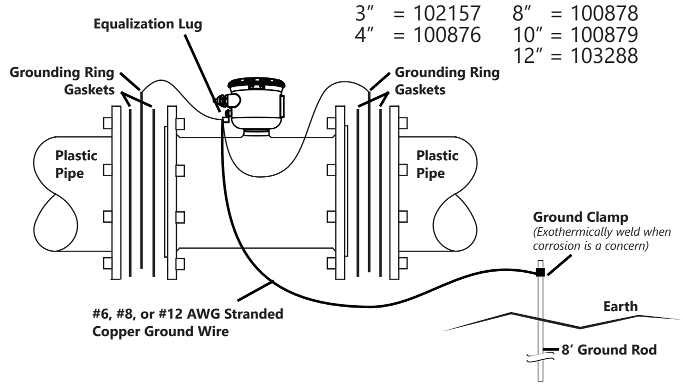
Metal Pipe Installations. To equalize the electrical potential of the fluid, the AG3000 meter, and the surrounding pipe, secure the flange plates (factory-installed on the equalization wire) to both pipe flanges at one of the bolt holes, as shown below. Be sure the lock washer fits between the pipe flange and the flange plate. For the best electrical bonding, remove rust and paint to expose clean, bare metal where the equalization flange plate lock washer contacts the pipe flange. Connection must be inspected periodically for corrosion to maintain the necessary low resistance connection.



Plastic Pipe and Electronically Noisy Installations. When the AG3000 is installed in plastic pipe or in an electrically noisy system (near a VFD etc.), grounding rings are recommended. As shown in the diagram below, the equalization wires should be solidly connected to the grounding ring tabs instead of the flange bolts as in metal piping installations. Where lightning is a threat, or in severe electrical environments, an optional connection to a nearby equipment ground or ground rod may be advisable.

Grounding Ring Part Numbers:

2″	= 104124	6″	= 100877
3″	= 102157	8″	= 100878
4″	= 100876	10″	= 100879
		12″	= 103288

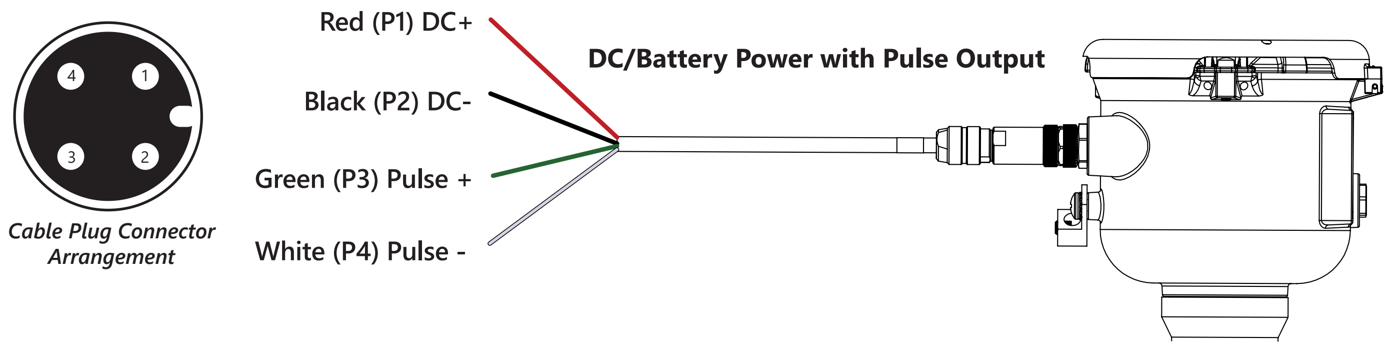


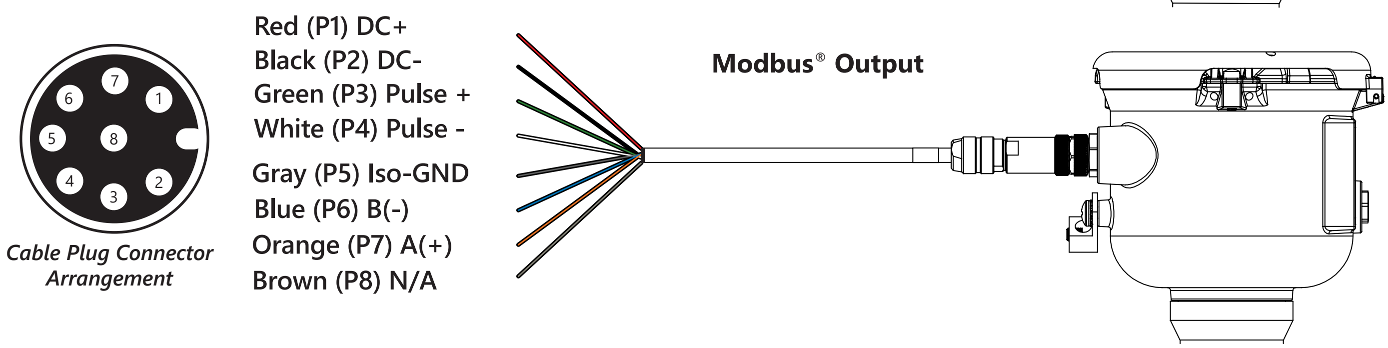
AG3000 General Cable Information

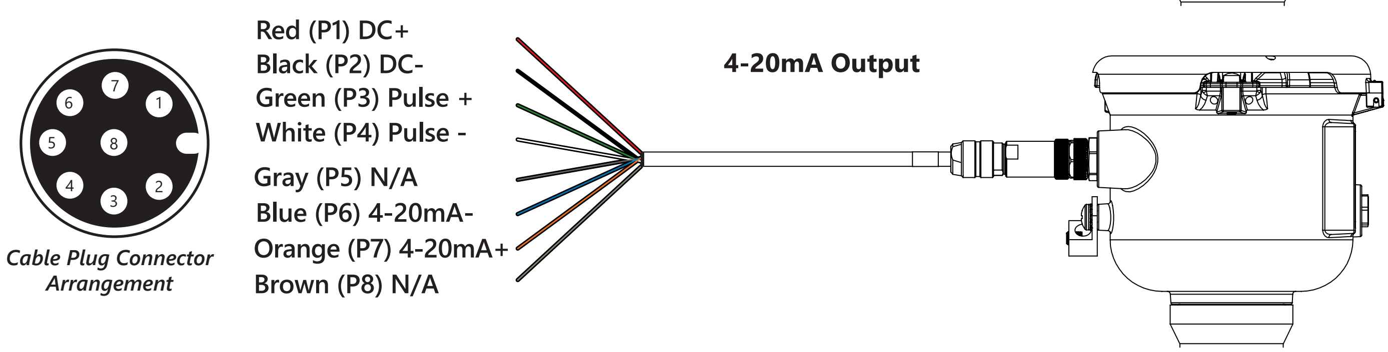
The AG3000 meter has two power/output cables that can be installed. The 4-pin cable contains the wires for DC power and pulse output. The 8-pin cable contains the wires for DC power and pulse, 4-20 mA or Modbus® output options when ordered. See diagrams below for details.

The AG3000 is available in either Battery or external DC versions.

WARNING: BACKUP BATTERIES ARE NOT INTENDED AS A PRIMARY POWER SOURCE OF A MAINS (DC or AC) CONFIGURED METER.



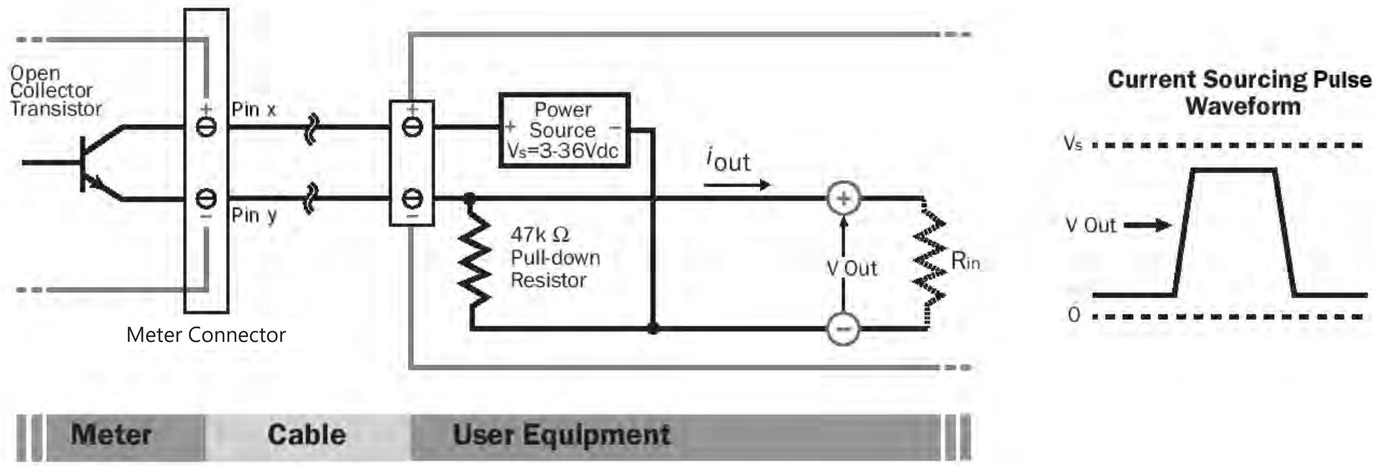




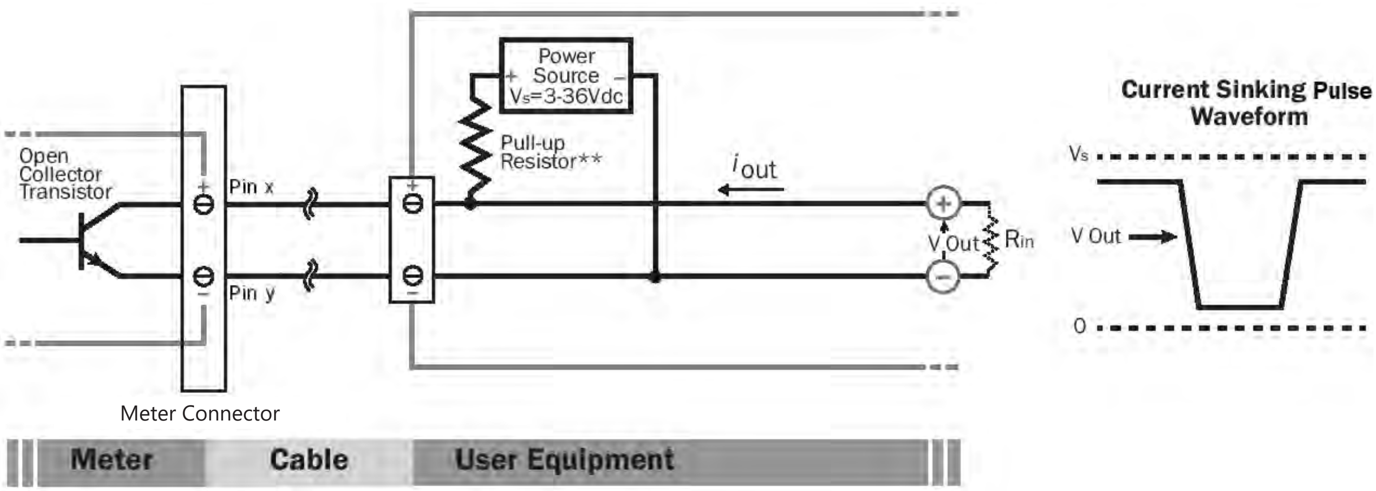
Option IDs

O ID		POWER SOURCE / OUTPUT(S)
BXX	=	BATTERY POWER / PULSE SCALED
BXS	=	BATTERY POWER / PULSE SCALED / MODBUS®
D1X/D2X	=	DC POWER / PULSE SCALED
D1L/D2L	=	DC POWER / PULSE SCALED AND 4-20mA
D1S/D2S	=	DC POWER / PULSE SCALED AND MODBUS®

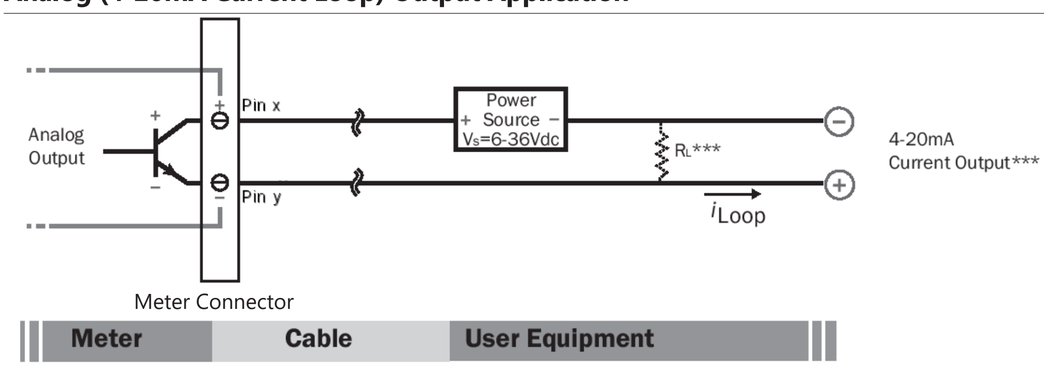
Pulse Output Application - Sourcing Mode (Recommended for Rin < 30kΩ)



Pulse Output Application - Sinking Mode (Recommended for Rin > 30kΩ)



Analog (4-20mA Current Loop) Output Application



*** Minimum resistor value is (100 x Vs) ohms. Higher resistances maybe used depending on frequency and cable length. Longer cables and high frequencies require lower resistance.*

**** Resistor RL converts 4-20mA current to voltage for voltage input only devices.*

Cable Shield. In general, the cable shield and its bare drain wire should be left unconnected at the user equipment end of the cable to minimize "ground loop" problems.

Pulse Output Configuration. A pulse output is standard on all models. Since this is an isolated output, the external equipment must include a DC power source to regenerate the pulse from the open-collector output (transistor equivalent of a contact closure). A pull-up or pull-down resistor may be needed if not included in the user equipment as shown in the diagrams. Both the power source and resistor may be supplied internally in some types of control and monitoring devices. If not, as for most PLC discrete input modules, they must be added externally at the module input terminals. The pulse output rate in volume units/pulse can be set by the user via the SETP tab on the meter's setup menus.

Because the pulse output of an AG3000 meter is set by the user, care must be taken to assure the output pulses do not exceed the maximum frequency of the meter while also ensuring a reasonable resolution.

K-factor: Remember that SETP is expressed in units totaled per output pulse (G/P if using gallons) while K-factors are expressed in pulses per gallon (P/G.) To determine K-factor from SETP, divide 1 by SETP (if SETP is expressed in gallons.) Conversely, 1 divided by the K-factor equals SETP

AG3000 meters that were initially configured as battery powered units have a maximum output frequency of 150 Hz. Those that were initially configured as powered units have a maximum output frequency of 200 Hz.

Because all pulse outputs (SETP) are configured in (rate) units totaled per pulse, all sizes of meters can be configured with the same SETP values. For example, if your rate is chosen as gallons per minute (GPM) the table below applies.

Pulse Units. The units of measure of SETP are independently selectable and are not tied to rate or total. Upon change of the SETP unit, the pulse output may take up to 10 seconds, or the duration of one pulse (whichever is longer) to take effect.

If Pulse Output is Inconsistent. The PDAMP filter may need to be increased.

Pulse Width Timing. The unit and value of SETP must be chosen to keep the duration between meter pulse outputs to less than 500 seconds.

Pulse Timing in Battery Powered Units. The output pulse width in battery powered units is short and varies with pulse frequency. (See table)

SETP	Flow Rate at 1 Hz (GPM)	Flow Rate at 200 Hz (GPM) *Powered Meters*	Flow Rate at 150 Hz (GPM) *Battery Powered Meters*
0.1	6	1200	900
0.2	12	2400	1800
0.3	18	3600	2700
0.4	24	4800	3600
0.5	30	6000	4500
0.6	36	7200	5400
0.7	42	8400	6300
0.8	48	9600	7200
0.9	54	10800	8100
1.0	60	12000	9000

Lower frequency output pulses (1 pulse for some particular number of gallons) can also be set.

Any output frequency can be determined by:

Rate (units/minute) ÷ SETP (units/pulse) = pulse/minute
Hz = pulse/minute ÷ 60 seconds / minutes

For reference/comparison only

K-factors and the equivalent SETP values for old style WMX units are shown below.

WMX	4"	6"	8"	10"	12"
K-Factor	16.36	6.31	3.34	2.15	1.53
SETP	0.06*	0.16	0.30	0.47	0.65

**Note that on the AG3000 you would need to choose a SETP value of 0.1 for the 4".*

Output Pulse Width of Battery Powered Units		
Output Pulse Frequency	**Output Pulse Width as a Percentage of the Pulse Period** (Pulse period = 1000 milliseconds/frequency)	
Zero to 1 Hz	Multiply the pulse period by 0.01	= Output Pulse Width (ms)
1 to 20 Hz	Multiply the pulse period by 0.05	= Output Pulse Width (ms)
20 to 100 Hz	Multiply the pulse period by 0.1	= Output Pulse Width (ms)
100 to 150 Hz	Multiply the pulse period by 0.15	= Output Pulse Width (ms)

Example: If frequency = 20 Hz then the pulse period = 50 milliseconds and pulse width = (.05 x 50 milliseconds) = 2.5 ms

Analog Output (4-20mA) Configuration.

(Not available on battery only units.)

Since the meter's analog output is isolated and passive, loop power must be supplied externally as shown previously. (In addition, an external resistor R_L will be needed to convert the loop current to voltage for voltage-only input devices.)

The meter's loop transmitter minimum voltage drop is 6Vdc which, with wiring resistance and loop power supply voltage, will determine the maximum resistance for R_L.

The flow rates corresponding to 4 and 20mA can be set by the user via the SET 4 and SET20 tabs on the meter's setup menus.

Note: As configured by the factory, any alarm state will force 22.8mA on the loop.
This can be changed to 3.2mA - see Technical Bulletin, 'iMAG4700/AG3000: Changing the 4-20mA Alarm'

Modbus® Serial Communication Configuration (factory configured**).**

These connections provide a half-duplex, isolated, RS485 serial communications port using the Modbus® messaging protocol. The TXD connection is the transmitted data output from the meter and RXD is the received data input to the meter. See Seametric's Modbus® Interface Description, LT-103393 (available at www.seametrics.com) for supported Modbus® message protocol and electrical interface specifications.

A 120-ohm termination resistor is built into the Modbus® option board but is shipped in the unused position. To engage the termination resistor, move the jumper on JP1 from position 3-4 to position 1-2.

Changing Flow Meter Settings

Home Screen and General Navigation

The HOME Screen displays flow volume, direction of the flow total and flow RATE along with status conditions such as Empty Pipe. Two buttons below the LCD display are used to access menu screens for viewing and changing meter setup parameters.

These two buttons are light sensors which can detect when a finger is covering them and activate upon release. Only three button touch actions are needed to control navigation through the menus, settings changes and back to the home screen.

HORIZONTAL SCROLLING:
Tap right button to scroll horizontally through menu tabs or move horizontally within a tab dialog when applicable.

SELECT:
Tap left button to change a highlighted item within a tab dialog.

ENTER/EXIT:
Hold left button while tapping right button once to enter or exit a tab dialog or to navigate between the HOME and other menu screens. (continue to hold the left button until after the right button is released.)

Changing Total Direction/Resetting Batch Totalizers

On the Main screen, hold ▶ and tap ▲ 7 times to scroll through the total direction options. Release ▶ to select a total direction.

Once BATCH FORWARD or BATCH REVERSE is selcted, tap ▶ four times to reset batch totalizer.

Entering Menu System

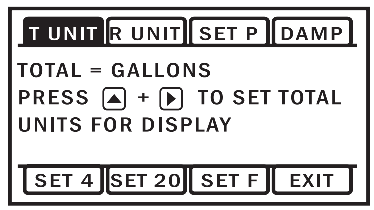
To enter the Menu System, perform the hold and tap sequence. The Passcode entry screen will display. The default passcode is 000000. If a different passcode has previously been set, use the ▲ and ▶ to enter that passcode. In either case, hold and tap again to move into the menu system. (*If you enter the wrong passcode, hold and tap again to return to the previous screen. See page 21 for information on how to change a passcode.)*

Making Selections

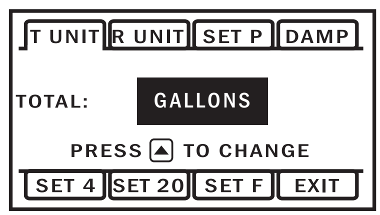
Once in the Menu System, move from tab to tab by tapping the right button. (See the next page for details on the various available tabs.)

Select the parameter. In the screen for the highlighted tab, you will see the current parameter value for that tab. Tapping the right button, move to the tab for the parameter you want to change.

In this example, the first line indicates that the current unit for the TOTAL is GALLONS. The next two lines tell you what to do next.



If you would like to change the TOTAL units, just perform the hold and tap sequence to bring up a screen to change the setting.



Select a new setting. Select the new setting by scrolling through a list of selections as in the screen illustration below by tapping the left button to find a different TOTAL unit.

Accept changes. To accept any changes you have made, perform the hold and tap sequence.

When finished making changes. When you are finished making changes, move to the EXIT tab using the right button.

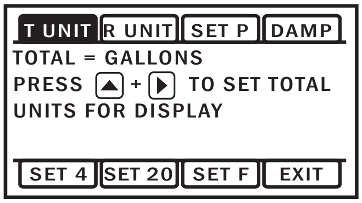
To return to the HOME screen, perform the hold and tap sequence.

Standard Menu Options

Note: Available options will depend on specific meter configuration. Not all options are available on all meters. **Options not ordered with your meter will not appear on the meter menu.**

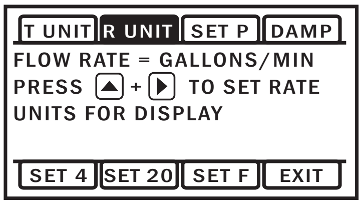
T UNIT

View or change TOTAL volume units



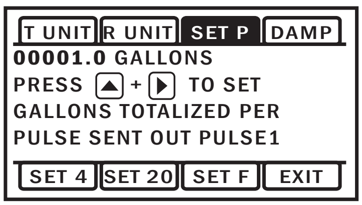
R UNIT

View or change flow RATE units



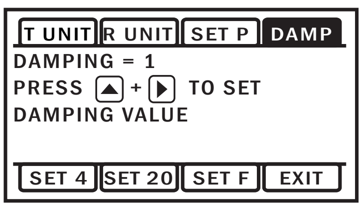
SET P

View or change pulse output scaling



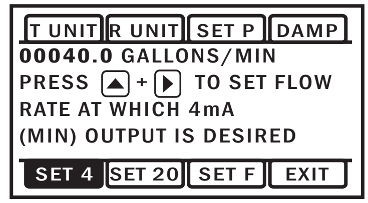
DAMP

View or change # of samples for rolling average.



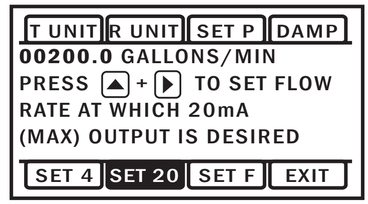
SET 4

View or change flow rate corresponding to 4mA. *(Externally powered units only)*



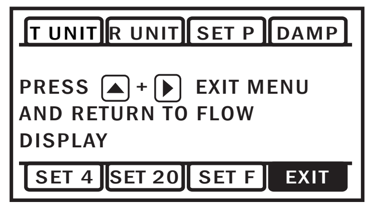
SET 20

View or change flow rate corresponding to 20mA. *(Externally powered units only)*



EXIT

Return to HOME SCREEN or enter SUBMENU



Special SUBMENU for Further Options

The EXIT tab in the MAIN MENU has a second function. If, instead of using the hold and tap sequence to return to the HOME screen, you tap ▲ seven times, you will be redirected to a SUBMENU screen from which you can access several more options.

Navigation in this SUBMENU is the same as for the MAIN MENU. Whenever you wish, go to the EXIT tab in the SUBMENU and perform the hold and tap sequence to return to the MAIN MENU.

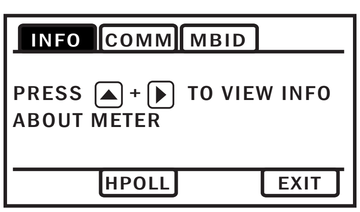
INFO: Meter model number, serial number, and firmware version.

COMM: Modbus® baud rate and parity.

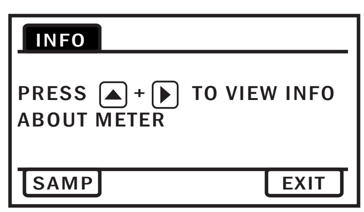
MBID: Modbus® address

SAMP: Sample rate *(Battery powered version only.)*

EXIT: Return to MAIN MENU or enter next submenu.



Sub-Menu



Sub-Menu - Battery Only Version

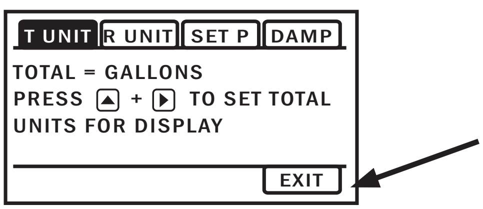
To Change a Passcode and Decimal Places

The AG3000 has a passcode system for restricting access to the menus. The AG3000 comes from the factory with the passcode set to 000000. When a user attempts to enter the menu system (see details on page 15), the passcode entry screen will be displayed.

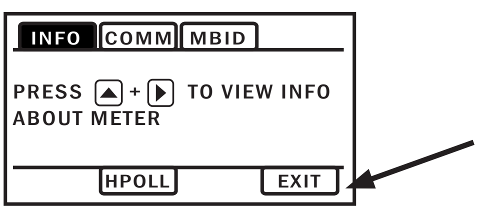
The default passcode is 000000. If a different passcode has previously been set, then the user must enter that passcode at this time. After entering the passcode, or leaving it at 000000 if using the default passcode, the user does the tap and hold sequence to move into the menu system.

To change the passcode, you must use the THIRD MENU screen. Access the THIRD MENU screen as follows:

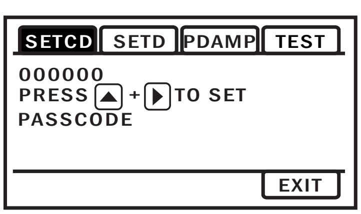
- Enter the main menu system, as described above.



- On the main menu, tab over to the EXIT tab and tap the up arrow five times. A SUBMENU screen will display.



- On the SUBMENU screen tab over to the EXIT tab and tap ▲ five times. The THIRD MENU screen will display.



- To set the PASSCODE, hold and tap on SETCD and then use the ▲ and ▶ to enter the new code.
- Hold and tap again to return to the THIRD MENU screen.
- Tab to EXIT, and then hold and tap to return to the SUBMENU.

To change the number of decimal places in the total

- To set the decimal point, hold and tap on SETD and then use the ▶ to move the decimal point.
- Hold and tap again to return to the THIRD MENU screen.
- Tab to EXIT, and then hold and tap to return to the SUBMENU.

PDAMP

PDAMP is used to view or change the number of samples for rolling average of pulse output.

TEST

TEST allows the user to initiate a fully functional, artificial flow rate for the purpose of testing other connected equipment. When TEST is applied, all features of the meter will function at the stated flow rate (in gallons per second).

For TEST to function, the meter must be filled (not EMPTY PIPE).

To enter a value into the TEST feature, navigate to the TEST tab and enter a flow rate value in the VAL screen (in gallons per second only,) then ▶ to the VAL box and ▲ to the ON screen. This will initiate the TEST feature. The next ▲ would bring you to the OFF screen, but you can 'hold and tap' the arrows to return you to the sub menu while the feature operates.

After use, the TEST feature must be turned OFF. If the TEST feature is not turned OFF, the stated static flow rate (in gallons per second) will be shown any time the meter is full or in a flowing condition. Flow values recorded by the meter while the TEST feature is operating are permanently recorded in the displayed TOTAL. It may be useful to note that these values are only written to permanent memory every 15 minutes and cycling all power within this 15 minute time frame will return the meter to its previous total.

Power Indicators

A power indicator is displayed in the lower left of the main display window.

Any meter powered from an external power source will display a power plug icon when running on external power. If the connection to external power is lost, the meter will switch to the backup battery and the power icon will switch to a battery symbol.

OK on the battery indicator means battery voltage is above 6.4 volts.

LO on the battery indicator means the battery is low and should be replaced soon.

Being powered by external DC or AC

Being powered by battery - voltage is sufficient

Being powered by battery - voltage is low

If display reads, 'BATT END' replace battery immediately.

Battery Powered Units

To 'wake up' a battery powered meter, you may need to hold the up arrow for 5 seconds and release. If the meter does not wake up on the first attempt, repeat the 5 second hold.

The AG3000 meter can come configured with one 7.2V 'D' size replaceable battery pack. In this configuration, the only option/output is the scaled pulse output which comes standard. The scaled output for the battery powered option has a maximum pulse rate of 150 pulses/second. Be sure to set your P value such that the meter will function properly over the flow range in your application. The sample rate of the meter is user selectable through the SAMP tab in the meter's sub-menu. Sample periods of 1/5, 1/3, 1, 3, 5, 15, 30, and 60 seconds can be selected. (A sample period of 5 seconds—5 year battery life—is the default.)

Larger sample periods will yield longer battery life but slower response time. Care must be taken to select a sample period that is suitable for your application. See the table below for the expected battery life as a function of sample period.

DAMP Settings for Battery Units

If SAMP (sample period) is set to <u>less than one second</u>, the DAMP value represents the number of seconds (plus one) used in the rolling average for the display. For example, if DAMP is set to four, then when the meter begins to show a flow rate, the rate displayed is the average of all the readings taken in <u>seconds</u> one through five (4 plus 1).

If SAMP (sample period) is set to <u>one second or longer,</u> the DAMP value represents the number of sample periods (plus one) used in the rolling average for the display. For example, if SAMP is set at three seconds and DAMP is set to four, then when the meter begins to show a flow rate, the rate displayed is the average of <u>samples</u> one through five (4 plus 1). Note that depending on the settings selected, it may take up to a minute for the displayed rate to take full advantage of the DAMP filter. When starting with an EMPTY PIPE it may take at least 30 seconds to register any flow.

Battery Life/Sample Period

For battery (BX) powered meters only.

Sensor sample period(s) (Seconds)	Expected battery life*
1/5 (0.2)	7 months
1/3 (0.33)	1 year
1	2.25 years
3	4 years
5	5 years
15	6 years
30	6.25 years
60	6.5 years

**Based on 75% battery capacity at room temperature with no option cards installed.*

NOTE: If a large percentage of the meter's life will be spent below 0.5 meters/second and above cutoff, battery life will be reduced.

BATTERY LIFE WITH MODBUS® OPTION!

IN THIS CONFIGURATION THE METER COMES STANDARD WITH PULSE OUTPUT. WHEN ORDERED WITH THE MODBUS® OUTPUT OPTION, BATTERY LIFE WILL BE REDUCED TO 1 YEAR, OR GREATER, BASED ON USAGE. REDUCE POLLING FREQUENCY AND MINIMIZE DATA COLLECTED IN ORDER TO MAXIMIZE BATTERY LIFE.

Troubleshooting

Problem	Probable Causes	Things to try...
Blank Display	Faulty wiring from power source to meter	Check for incorrect wiring. Measure voltage with DMM where red and black wires connect to terminal block TB1 on back side of display. Verify correct polarity and confirm that voltage is steady and between 9Vdc and 32Vdc
	Battery has not been plugged in	Plug in the battery
	Dead battery	Replace battery
Flow rate reading fluctuates excessively when flow is unchanging	Excessively turbulent or unsteady flow due to partially closed valves or other flow obstructions	Eliminate or minimize causes of flow disturbances or increase meter damping
	Pipe not full	Provide back pressure or other means to ensure pipe is filled
	Pulsing flow due to combining multiple upstream flow sources	Move connection point further upstream
	Insufficient mixing of upstream chemicals	Move chemical injection downstream from meter
	Low fluid conductivity < 20 µS/cm	Replace with different type of meter
	Noisy electrical environment	Improve grounding at meter and nearby potentially noisy electrical equipment. Increase distance between meter and electrical noise sources.
	Defective or noisy AC switching power supply	Replace power supply
Flow Rate appears correct but pulse/ frequency output is low, erratic or absent	Wiring incorrect	Compare wiring with appropriate wiring recommendations
	External device input impedance too low	Use sourcing rather than sinking interface connection
	Cable too long	Reduce interface pull-up resistance
Flow Rate appears correct but pulse/frequency output is erratic and/or too high	Electrical noise sources interfering with pulse frequency signal	Isolate, remove or reduce noise sources. Move meter control cable away from noise sources. Increase pulse damp setting (PDAMP)
	Wrong type of cable	Use only twisted pair cable and ensure both signal wires are on same twisted pair
	Grounding problem	Improve or try different grounding method

Error Messages

Under certain conditions an error message may be displayed.

Message	Description	Notes
INIT	Initialization is occurring during power up.	
EMPTY PIPE	Fluid is not detected between the sensing electrodes.	Loop output = 22.8mA
LO in battery icon	Battery is getting low, replace soon. Meter still functions.	Above 6.4V, OK appears in icon
BATT END	Battery is very low (approx. 6.1V). Totalizer stops updating.	Loop output = 4mA
LOW VOLT	Incoming external power is very low and backup battery is dead or not connected	Loop output = 4mA
COIL FAIL	Coil current too high or too low (short or open).	Loop output = 22.8mA
COMM FAIL	Communication between transmitter and sensor board fails.	Loop output = 22.8mA
OVER RANGE	Rate exceeds number of digits that can be displayed. Adjust units.	Loop output = 4mA

The limited warranty set forth below is given by Seametrics, with respect to Seametrics brand products purchased in the United States of America.

Seametrics warrants that products manufactured by Seametrics, when delivered to you in new condition in their original containers and properly installed, shall be free from defects in material and workmanship. **Seametrics products are warranted against defects for a minimum period of two (2) years from date of installation, unless otherwise specified, with proof of install date. If no proof of install date can be provided, warranty period will be two (2) years from date of shipment from Seametrics, as defined on Seametrics' invoice.** Seametrics' obligation under this warranty shall be limited to replacing or repairing the part or parts, or, at Seametrics' option, the products, which prove defective in material or workmanship. The following are the terms of Seametrics' limited warranty:

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b. Any defective part or parts must be returned to Seametrics' factory or to an authorized service center for inspection.
c. Buyer will prepay all freight charges to return any products to Seametrics' factory, or another repair facility. as designated by Seametrics.
d. Defective products, or parts thereof, which are returned to Seametrics and proved to be defective upon inspection, will be repaired to factory specifications.
e. Seametrics will deliver repaired products or replacements for defective products to the buyer (ground freight prepaid) to the destination provided in the original order.
f. Products returned to Seametrics for which Seametrics provides replacement under this warranty shall become the property of Seametrics.
g. This limited warranty covers all defects encountered in normal use of Seametrics products, and does not apply to the following cases:
    i. Loss of or damage to Seametrics product due to abuse, mishandling, or improper packaging by buyer
    ii. Failure to follow operating, maintenance, or environmental instructions prescribed in Seametrics' instruction manual
    iii. Products not used for their intended purpose
    iv. Alterations to the product, purposeful or accidental
    v. Electrical current fluctuations
    vi. Corrosion due to aggressive materials not approved for your specific product
    vii. Mishandling, or misapplication of Seametrics products
    viii. Products or parts that are typically consumed during normal operation
    ix. Use of parts or supplies (other than those sold by Seametrics) which cause damage to the products, or cause abnormally frequent service calls or service problems
h. A new warranty period will be established for repaired products, or products replaced during the original warranty period.
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APPENDIX D
Data Collection List (Roberti Ranch)

Irrigation Efficiency Studies		Irrigation Cycle 1	2	3	4
General	Field Number	Roberti #13 LEPA	Roberti #13 LEPA	Roberti #13 LEPA	Roberti #13 LEPA
	Crop	Alfalfa	Alfalfa	Alfalfa	Alfalfa
	Crop Age (years)				
	Acres Irrigated				
	Cutting Number/Cycle				
Start Irrigation	Date of Water First Applied				
	Time Water first Applied				
	Well Meter reading pre-Irrigation				
	Start Motor Speed				
During Irrigation	Motor Speed adjustments (Date, Time, Speed)				
	Soil Moisture Observations (Date, Time, Observation)				
Post-Irrigation	Date Stopped Water Application				
	End Time Water Applied				
	Well Meter reading Post-Irrigation				
	Ending Motor Speed				
Yield	Alfalfa Total Tonnage				
	Alfalfa Yield (ton/acre)				
Quality, as measured	Dry Matter (DM)				
	Crude Protein (CP)				
	Non-Structural Carbohydrates (NSC)				
	Total Digestible Nutrients (TDN)				
	Neutral Detergent Fiber (NDF)				
	Relative Feed Value (RFV)				
	Acid Detergent Fiber (ADF)				

Irrigation Efficiency Studies		Irrigation Cycle			
		1	2	3	4
General	Field Number	Roberti #10 MESA Baseline	Roberti #10 MESA Baseline	Roberti #10 MESA Baseline	Roberti #10 MESA Baseline
	Crop	Alfalfa	Alfalfa	Alfalfa	Alfalfa
	Crop Age (years)				
	Acres Irrigated				
	Cutting Number/Cycle				
Start Irrigation	Date of Water First Applied				
	Time Water first Applied				
	Well Meter reading pre-Irrigation				
	Start Motor Speed				
During Irrigation	Motor Speed adjustments (Date, Time, Speed)				
	Soil Moisture Observations (Date, Time, Observation)				
Post-Irrigation	Date Stopped Water Application				
	End Time Water Applied				
	Well Meter reading Post-Irrigation				
	Ending Motor Speed				
Yield	Alfalfa Total Tonnage				
	Alfalfa Yield (ton/acre)				
Quality, as measured	Dry Matter (DM)				
	Crude Protein (CP)				
	Non-Structural Carbohydrates (NSC)				
	Total Digestible Nutrients (TDN)				
	Neutral Detergent Fiber (NDF)				
	Relative Feed Value (RFV)				
	Acid Detergent Fiber (ADF)				