Appendix A

Ground Water Discharge Permit
Permit No. UGW15001

PACIFICORP

HUNTER RESEARCH FARM

WASTE WATER LAND APPLICATION PLAN

04
Revision

02/14/2020
Date

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Appendix A
Hunter Research Farm
Waste Water Land Application Plan

1. Objective

The Hunter Research Farm was established on company owned property to dispose of plant waste water, as an efficient, cost effective and environmentally sound method to accomplish disposal.

The amount of water used on the Hunter Research Farm is carefully controlled to ensure that all the waste water is evaporated, absorbed by vegetation, or otherwise used so that no waste water escapes the company owned property into surface water or percolates through the soil and into the ground water system. This is accomplished by balancing environmental and weather information using sophisticated weather data and computer modeling through Utah State University and/or private consultant, by contract. The ground water system is monitored semi-annually using monitoring wells located in strategic places around the farm properties. This information is reported to the Utah Division of Water Quality semi-annually.

The Hunter Research Farm operates under the following set of objectives:

1. Dispose of power plant waste water by efficient agricultural irrigation within environmental regulations
2. Perform research and monitoring programs, which support the continued use of waste water in agricultural irrigation.
3. Operate the farm in the most economical and efficient manner possible.
4. Investigate revenue-generating options to reduce the operating cost of the Hunter Research Farm.

The Hunter Research Farm is composed of an estimated nine different soil series with fifteen different soil types within these nine different series (USDA et al., 1970). A complete text of each soil series and soil type are contained in **Appendix A**. The many different soil types pose a very complex challenge to uniform irrigation application and consistent crop growth over the field surface. Each soil series also offers a complicated set of water table and ground water problems. Water infiltration and holding capacities vary by soil type. Depth limitations and other problems with the soil profiles pose differing sets of problems for uniform irrigation application on the farm.

In order to comply with the first research farm objective, any crop that is grown must have a high water consumptive use, be salt tolerant, have a perennial growth habit, be deep rooted, and tolerant of elements contained in the waste water.

Alfalfa is grown on the largest amount of the acreage possible because of its deep root system, high water consumptive use factor, perennial growth habit, salt tolerance and high tolerance to boron. The choice for alfalfa is also supported by research conducted by Dr. John Hanks (Hanks et al., 1990), which showed that alfalfa yields are higher when irrigated with saline wastewater than when irrigated with fresh water. Small grains are used in a crop rotation with alfalfa for weed control and maximum nutrient utilization.

2. Procedure

2.1. Soil Moisture Determination

Field determination of the initial level of available moisture is essential where correct soil moisture control for high water use and efficient irrigation in the crop with no leaching is required. During the entire season, amount and frequency of irrigation should be varied in accordance with the actual moisture used by the crop during any growing period. At the beginning of the irrigation season, the soil moisture level should be known before staring irrigation. This is accomplished each spring; farm wide, by using the annual water balance information supplied by the evapotranspiration instrumentation and can be checked with the manual, "feel" method (**appendix B**) of soil moisture determination. This soil moisture information is used to give a starting point for irrigation requirements at the beginning of the irrigation season.

2.2. Actual Evapotranspiration (ET_a) Determination

A procedure to measure the amount of water lost from the soil surface through evaporation and the amount of water lost through transpiration from the crop canopy, evapotranspiration (**ET**) (**appendix C**), helps to determine the amount of water that is needed to be introduced, by irrigation, into the soil profile for continued crop production and maximum water utilization. The ET rate on the Hunter Research Farm is determined by using the Eddy Covariance instrument pack, installed in the middle of an alfalfa (Medicago sativa, L.) field on the Hunter North or West Farm, with enough fetch to measure ET over the fields (500 foot radius from the station).

The watering rates at the Hunter Research Farm are carefully monitored and controlled to prevent surface runoff and deep percolation, so as to minimize impacts to surface water and ground water. In the water budget method, the moisture in the soil is regarded as being a balance between what enters it as a result of precipitation and irrigation, and what leaves through evapotranspiration. The budget becomes merely a balance of putting back into the soil, through irrigation, water that is lost through ET. This is achieved by irrigation at or below the reported daily ET_a rate.

2.3. Application Rates

Application rate of a sprinkler system is the rate at which water is applied, expressed in units of inch/hour. The Hunter sprinkler system is designed so that the average application rate over the irrigated area is less than the basic intake rate of the surface soil to prevent runoff. The design application rate for the Hunter Research Farm is 0.25 inches/hour. At this rate, approximately 2.75 inches of waste water is applied during an eleven hour set. Application rates per sprinkler head are estimated by size of the nozzle in the sprinkler head and the pressure at which it operates (**appendix D**).

2.4. Irrigation Frequency

Irrigation frequency refers to the number of days between irrigations. In practice, irrigation frequency is determined by means of water balance calculations, using available soil water capacity and the ET_a value calculated by the Eddy Covariance station.

Waste water irrigation frequency on the Hunter Research Farm is determined by using the daily ET_a rate over the previous days since last irrigation to get the total water usage from the available soil reservoir. When approximately 2.5 inches of water has been lost, as indicated by ET_a measurements, then an irrigation sequence is scheduled. The weather forecast is also taken into account so as to anticipate any potential precipitation events.

3. Controls

The primary control that is in place on the Hunter Research Farm to prevent surface runoff or leaching to ground water is the judicious application of the waste water in relation to ET_a measurements. The following measures are in place to handle the infrequent upset condition, or the unusual weather event, such as a 50 year storm.

3.1. Surface runoff

Each area of the farm is surrounded by an earthen berm that is used to channel any excess surface water to a retention pond. The ponds are of adequate size to contain a sprinkler system spill or system failure of up to 10 hours. These same ponds are designed to contain the surface runoff of a significant precipitation event. The intent of these ponds is that the bottoms would seal over time as water moved clay particles into the pore spaces. Water would then be lost through evaporation or by pumping into tank trucks.

Any surface spills that do enter waters of the State, are immediately reported to the State Division of Water Quality.

3.2. Ground Water

Ground water is protected from waste water contamination by careful control of the application of waste water from irrigation. By limiting the amount of waste water applied to a quantity less than the volume of water lost through evapotranspiration, the amount of water in the soil profile will not exceed the capacity of the soil and will not allow leaching into the shallow aquifers under the farm fields.

4. Records and Reports

4.1. Irrigation Records

Knowing how much waste water has been applied to any area is essential to a successful waste water land application plan. An irrigation record is kept in the Hunter Research Farm office. Each sprinkler line is identified on the farm by its own name (**Appendix E**). The name contains the farm area where it is located (north, east or west), the field name, and the direction locator (east, west, north, south or center). The number of risers available for each sprinkler line is also recorded. For each of these risers, there is a record of how many sprinkler heads are on the line for that riser setting (**Appendix F**). Each day the riser position of each sprinkler line on the farm that is running is recorded. The duration of the set is recorded daily. An example of the daily irrigation record sheet is contained in **Appendix G**. Knowing the number of sprinkler heads, the operating pressure and the length of time of the irrigation set, the volume of water applied for that area can be calculated. Using this number and the TDS value for the waste water, a rough estimate of the amount of salt applied can also be calculated.

4.2. Flow and Storage Records

The Hunter Research Farm uses three inline propeller type *McCrometer* flow meters to measure the gross amount of waste water delivered to each area of the farm. Flow is measured instantaneously in gallons per minute (gpm) and a totalizing meter measures total flow in acre feet (acft). One flow meter is located in the main water delivery line (mainline) from Waste Water Pond #1 before it branches to go to the north, west and east lake production areas of the farm. The second flow meter is located in the delivery line from Waste Water Pond #2 metering water that is delivered to the east farm. A third meter is located in another irrigation delivery line coming from Waste Water Pond #2 that feeds additional water to the west, north and east lake areas of the Hunter Research Farm.

The present record keeping scheme has these three flow meters being read weekly by the farm personnel. Waste water output to Waste Water Pond #1 by the power plant is recorded weekly also. This information is recorded by one flow meter located at the outfall of the waste water holding basins as the water enters Waste Water Pond #1. The information is forwarded to the manager of research farms. The manager takes the data and records the weekly irrigation rates for the three areas of the Hunter Research Farm and the amount of waste water added to the storage pond by the Hunter power plant. An irrigation water sample is also taken from each of the Waste Water Ponds. These samples are used to report the TDS and pH of the waste water. Weekly irrigation values and acres irrigated, by farm area are reported to ET Consultant to be compared against the actual ET (ET_a) curve for addition into the annual report from ET Consultant to PacifiCorp. The daily ET_a reports and monthly ET_a summaries are also kept on file in the research farm office.

The actual level of waste water in the two Waste Water Ponds is also recorded weekly by reading the distance of a given point to the water surface. This data is used to calculate the amount of waste water that remains in storage in the two ponds. At the beginning of the irrigation season, this storage volume data is used to determine the number of acres that will be required to be irrigated on the farm, in order to dispose of all the waste water in an efficient manner and within environmental regulations. This data is also used weekly, as a gross check, of the flow meters, on the water balance of water out to the farm and water into the waste water ponds from the power plant.

4.3. Crop Records

Crop field records, indicating which crops were grown where, are recorded and saved. Crop inputs, such as seed, fertilizer and pesticides are also recorded.

4.4. Groundwater Report

Semi-annual ground water and surface water samples are collected. Spring samples are collected in late March or early April before or just as waste water irrigation commences and the fall sampling is completed during late October or early November, as waste water irrigation is finishing or has been terminated. Results of these two sampling events are reported as required in the ground water permit. If any anomalies or values above protection levels are observed, they are indicated in the cover letter of the report.

4.5. Calculated Application Rate

The actual irrigation rate in inches of waste water applied will be calculated each week, combined with the weekly precipitation and compared with the measured actual evapotranspiration provided by the ET consultant. The farm manager will be responsible for this weekly evaluation and will prepare a report each month during the irrigation season to document the values. The report will be submitted to the environmental engineer. The report will contain the following:

a. Dates of each weekly period
b. Weekly flow quantity, totaled from the several flow monitors, in acre feet
c. Number of actively irrigated acres
d. Total precipitation during the week, in inches
e. Calculated irrigation rate, in inches
f. Total water applied, sum of irrigation and precipitation, in inches
g. Actual evapotranspiration amount for the week, in inches
h. Water balance calculation, in inches
i. Comments, e.g. estimated field moisture determinations, adjustments, etc.

The calculated irrigation rate will be determined by the following formula:

$$\text{Irrigation rate} = \frac{\text{Total gallons} \times 12}{\text{Acres irrigated} \times 7.481 \times 43{,}560}, \quad \text{inches}$$

The acres irrigated value is determined by the following formula:

$$\text{Acres irrigated} = \sum \frac{(N * SH * SR)}{43{,}560} \text{ for each irrigation line used}$$

N = number of sprinkler heads on the irrigation line
SH = spacing between sprinkler heads on the line, in feet, equals 40’
SR = spacing between the risers, in feet, equals 60’

The weekly water balance calculation will be found by taking the initial available soil moisture reading and subtracting the weekly ET_a sum and adding any irrigation and precipitation values. Subsequent water balance numbers are calculated by taking the previous week’s soil moisture number and adding the total water applied plus precipitation and subtracting the ET_a for the week to get a value in inches.

$$A_m = \sum ET_a - (I + P)$$

Where A_m = Available soil moisture, inches
ET_a = Sum of weekly actual evapotranspiration, inches
I = Irrigation amount, inches
P = Precipitation, inches

The precipitation and evapotranspiration rate are reported from the ET station instruments to the farm manager’s office every day with the previous day’s values.

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Appendix A **Soil Series and Types**

The Billings series consists of soils that are moderately fine textured, calcareous, and well drained or moderately well drained. These soils are on alluvial fans, on flood plains, and in narrow alluvial valleys. They have formed in alluvium that washed from alkaline, gypsum-bearing marine shale. The vegetation is dominantly greasewood, shadscale, galletagrass, and indian ricegrass. Elevations range from 4,000 to 6,500 feet. The annual rainfall ranges from 6 to 11 inches, and the frost-free season ranges from 110 to 160 days. The mean annual temperature of the soil ranges from 47° to 54° F.

In a typical profile, the surface layer is light brownish gray, strongly calcareous, hard silty clay loam about 11 inches thick. The underlying material is also light brownish-gray, mainly silty clay loam that is weakly stratified with thin layers of loam or clay loam. The profile contains crystals, veins, or soft nodules of gypsum at a depth below 20 inches.

Nearly all the acreage has been cleared and planted to irrigated crops, mainly alfalfa, small grains, corn, pasture plants, and sugar beets. Areas that have not been cleared are used for spring and fall range.

Billings silty clay loam, 1 to 3 percent slopes (BlB)- This soil has the profile described as typical of the series. In some places the underlying material contains thin layers of loam or clay loam. Veins, crystals, or nodules of gypsum are common below a depth of 122 to 200 inches but occur erratically, depending on the source of sediment.

Included with this soil in mapping were spots, generally less than 2 acres in extent, which are strongly affected by salt and alkali. Also included were some loamy soils, small areas of clayey soils, and some places, especially below shaly colluvial slopes, where gravel is on the surface.

This Billings soil is well drained and is moderately susceptible to erosion. It retains about 11 inches of water, but only 5 inches of water is readily available to plants. Runoff is medium, and permeability is slow. Roots penetrate deeply. The frost-free period is 110 to 130 days in 3 out of 4 years. Natural fertility is low, but fertility can be increased by applying manure and commercial fertilizer. This soil is fairly hard to work. The seedbed is more easily prepared if the soil is plowed in fall when it is moist and is allowed to remain rough over winter, than when plowing is done in spring.

This soil is used for irrigated alfalfa, small grains, corn, pasture, and sugar beets. Alfalfa yields two crops and part of a third. Corn does not mature for grain and is used for ensilage or is pastured. Alfalfa generally responds to phosphate; small grains, corn, and pasture plants respond to fertilizer containing nitrogen.

The soil generally needs to be leveled so that water can be distributed evenly. Leveling causes no damage if done when the soil is fairly dry. Many areas have already been leveled, and many areas of this soil are still in range.

Billings silty clay loam, deep waterable, 1 to 3 percent slopes (BsB) – This moderately well drained, moderately saline soil generally occurs with other poorly drained, saline soils. It is similar to and occurs with Billings silty clay loam, 1 to 3 percent slopes, but it is lower on the slopes.

The water table fluctuates with the season, but generally it is 36 to 60 inches below the surface. The effects of this water table are evident from the generally spotty appearance of the surface, caused by the accumulation of salts and alkali. This soil typically is mottled were some areas, ranging from 1 to 3 acres in extent, which are very strongly affected by salts and alkali.

Adequate drainage is difficult to maintain in this soil. To control wetness, ditches and canals should be lined and over irrigation avoided. These practices are more effective than artificial drainage, and they also help to reduce losses of irrigation water. The soil retains about 12 inches of water, but only about 4.5 inches is readily available to plants.

Irrigated pasture is the main use of this soil. Alfalfa and grain crops are grown, but yields of these crops are erratic.

Soils of the Chipeta series are calcareous, well drained, moderately fine textured, and gently rolling to moderately steep. They occupy shale hills and have formed in residuum that weathered from alkaline, gypsum-bearing marine shale. The vegetation is mainly mat saltbush, Gardner saltbush, and shadscale. Elevations range from 4,000 to 6,500 feet. The annual rainfall is 6 to 11 inches, and the mean annual soil temperature is 47° to 54° F. The frost-free season is 110 to 160 days.

In a typical profile, the surface layer is light brownish-gray, hard silty clay loam about 5 inches thick. The underlying material is light brownish-gray, slightly to moderately saline silty clay and silty clay loam. Slightly weathered marine shale bedrock is at a depth of about 17 inches.

Most areas of these soils are used for range. Small areas have been cleared and are used for irrigated alfalfa, grain, and pasture.

Chipeta-Badland association, 3 to 30 percent slopes eroded (CBF2). – This mapping unit is dominantly Chipeta silty clay loam, 3 to 20 percent lopes eroded, but about 20 percent of it consists of areas of Badland and of minor areas of Persayo soils. Badland generally has slopes of less than 30 percent, but in places slopes of as much as 50 percent were included in mapping.

In most places the profile of the Chipeta soil in this mapping unit is about 10 inches thick. Otherwise, the profile is like the one described for the series. The Chipeta soil typically is saline. After a rain, numerous white, salty spots are on the surface. The vegetation is mainly mat saltbush and Castle Valley clover.

Runoff is rapid, and erosion is active. The soils are readily dispersed by raindrops, and the susceptibility to further erosion is very high. Sheet and rill erosion are common. Runoff from the soils of this mapping unit accelerates gully erosion on the lower lopes.

This mapping unit is suited only to range.

Chipeta-Persayo association, 1 to 3 percent slopes (CPB),- This mapping unit consists of about 60 percent Chipeta silty clay loam, 1 to 3 percent slopes, and of about 40 percent Persayo loam, 1 to 3 percent slopes. These soils are intermingled and occur in no consistently identifiable pattern. Consequently, they were not separated in mapping. As a rule, the Chipeta soil is on ridges and has stronger slopes than the Persayo soil.

Included in the mapping were some areas of very shallow unnamed soils. Also included were other soils that are 20 to 40 inches thick over shale and small areas, generally less than 1 acre in extent, of strongly saline-alkali soils.

The profile of Chipeta silty clay loam, 1 to 3 percent slopes, is the one described as typical for the series. In most places this soil is 10 to 20 inches thick over shale. It has good drainage and is slowly permeable. Runoff is medium, and the susceptibility to erosion is moderate. Roots penetrate to the shale and then spread horizontally. This Chipeta soil retains about 3 inches of available water. The soil is hard to work and to irrigate. Leveling is not practical, because this soil is too shallow.

Chipeta-Persayo association 3 to 20 percent slopes, eroded (CPE2). – About 60 percent of this mapping unit is Chipeta silty clay loam, 3 to 20 percent slopes, eroded, and about 40 percent is Persayo loam, 3 to 20 percent slopes, eroded. These soils are intermingled and occur in no consistently identifiable pattern. The Chipeta soil generally is on ridges and has stronger slopes than the Persayo soil.

Included in the mapping unit were areas of soils having slopes of 1 to 3 percent and small areas of shale outcrop, or Badland. Also included in places were small spots that are strongly saline.

The soils in this mapping unit are highly susceptible to further erosion. Runoff is rapid, and it causes accelerated sheet and gully erosion. Many areas contain gullies that are 2 to 5 feet deep and 100 to 300 feet apart. A moderate amount of sheet erosion has taken place.

The soils in this mapping unit are suited to range and are used for that purpose.

Soils of the Persayo series, are calcareous, well drained, gently sloping to steep, and moderately fine textured. They occur on hills and have formed in residuum that weathered from shale. The vegetation is mainly gallatagrass and shadscale. Elevations range from 4,000 to 6,500 feet. The annual rainfall is 6 to 11 inches, and the mean annual soil temperature ranges from 47° to 54°F. The frost free season is 110 to 160 days.

In a typical profile, the surface layer is light brownish gray loam about 1 inch thick. The underlying material is light brownish-gray loam and silty clay loam that contains a weak to moderate gypsum horizon. Shale bedrock is at a depth of about 12 inches.

Persayo soils are used mainly for spring and fall range.

Persayo-Chipeta association, 1 to 20 percent slopes, eroded (PCE2), - About 60 percent of this mapping unit is Persayo loam, 1 to 20 percent slopes eroded, and 40 percent is Chipeta silty clay loam, 3 to 20 percent slopes, eroded. These soils are intermingled and occur in no identifiable pattern. The Chipeta soil generally is on ridges and has stronger slopes than the Persayo soil.

Included in the mapping were areas of 1 to 5 acres made up of a very strongly saline soil and of areas of a moderately deep soil. The Persayo soil has the profile described as typical of the series. It is well drained and has moderate permeability. Roots penetrate to the shale, and then they spread horizontally. This soil holds 1 to 3 inches of available water, the amount depending on the depth to bedrock. Runoff is medium, and the susceptibility to erosion is moderate.

The Chipeta soil has a profile similar to the one described as typical for the Chipeta series, except that the slopes are stronger and it is eroded. Rill and gully erosion are active.

The soils in this mapping unit are used mainly for spring and fall range, but in places they are used for irrigated pasture. Sheet erosion is active, and in many places shallow gullies have cut into the shale bedrock.

Soils of the Hunting series are deep, gently sloping, and slightly strongly saline. They are also medium textured and are somewhat poorly drained. These soils are on alluvial fans and flood plains and in narrow alluvial valleys, where they have formed in alluvium that washed from marine shale and sandstone. The vegetation is mainly saltgrass or redtop grass, but greasewood grows in places. Elevations range from 4,000 to 6,500 feet. The annual rainfall is 6 to 11 inches, and the mean annual soil temperature is between 47° and 54° F. The growing season ranges from 110 to 160 days.

In a typical profile, the surface layer is light brownish-gray, strongly calcareous loam about 9 inches thick. The underlying material is light brownish-gray and grayish-brown loam that contains a large amount of lime. Distinct mottles are at some depth between 20 and 40 inches.

The Hunting soils have a water table that is 20 to 40 inches below surface. Most areas of Hunting soils are cultivated. Crops grown under irrigation are alfalfa, small grains, and sugar beets. Some areas are used for irrigated pasture.

Hunting loam, moderately saline (1 to 3 percent slopes) (Hs). **-** The profile of this soil is similar to the one described as typical for the series, except that it is moderately saline.

Included in mapping were nearly level areas in which the surface layer is silty clay loam 8 to 14 inches thick. Also included were spots, generally less than 1 acre in extent, of strongly saline soils.

Soil limitations caused by the water table and accumulations of salts are more severe in areas that receive seepage from irrigation ditches and canals. In some places over irrigation contributes to wetness. Salinity has reduced the amount of water readily available to plants to about 3 inches. Preventing losses of water through over-irrigation and through seepage ditches and canals improves soil drainage and helps in reclaiming this soil.

The main use of this soil is for irrigated pasture. Crops should be selected for their tolerance to salt. Alfalfa and small grains are grown, but this soil is not well suited to these crops.

The Killpack series consists of well-drained, moderately fine textured, slightly to moderately saline soils. The soils have formed in residuum that weathered from clayey marine shale bedrock, and they contain weak to moderate salt of gypsum horizons. They are nearly level or gently sloping and occur in areas of small to moderate size on shale hills, generally below the Chipeta or Persayo soils. The depth to shale is 20 to 40 inches. Elevations range from 5,000 to 6,500 feet. The annual rainfall is 6 to 11 inches, and the mean annual soil temperature is 47° and 54° F. The frost-free season is 110 to 130 days.

In a typical profile, the surface layer is grayish-brown, slightly saline, strongly calcareous, hard clay loam about 9 inches thick. The underlying material is light brownish-gray, slightly and moderately saline clay loam or shaly silty clay loam. Light brownish-gray weathered shale bedrock is at a depth of about 29 inches.

The Killpack soils are used for range, cultivated crops, and irrigated pasture. Crops grown under irrigation are alfalfa, corn, small grains, and sugar beets, but the soils are not well suited to these crops or to irrigated pasture.

Killpack clay loam, 1 to 3 percent slopes (KlB)- The profile of this soil is the one described as typical of the series. Included in mapping were small areas in which the soil is thicker than 40 inches and places where it is less than 20 inches thick over shale. Also included were small areas of strongly and very strongly saline soils.

Drainage is good, and permeability is slow. Runoff is medium, and the susceptibility to erosion is moderate. Roots penetrate to the shale, and then they spread horizontally. About 4 to 5 inches of water is retained by this soil, but only about 2 to 2.5 inches, the amount depending on the depth to shale, is readily available to plants. This soil is hard to work, and generally it is hard to irrigate. The seedbed is more easily prepared if this soil is plowed in fall when it is barely moist, and is allowed to remain rough over winter, than when it is plowed in spring.

This soil is used for spring and fall range, for irrigated pasture, and for irrigated alfalfa and small grains. The growing season is only long enough for two full crops of alfalfa and for part of a third to mature.

The Penoyer series consists of well-drained, calcareous soils that are medium textured. These soils occupy medium to large areas of alluvial fans, flood plains, and alluvial plains on the bottoms of canyons. They have formed in alluvium from sandstone, limestone, and basic igneous rocks. The natural vegetation is mainly sagebrush, Indian ricegrass, galletagrass, and shadscale. Elevations range from 4,000 to 6,500 feet. The annual rainfall is 6 to 11 inches, and the mean annual soil temperature is 47° to 54° F. The frost-free season is 110 to 160 days.

In a typical profile, the surface layer is light brownish-gray, strongly calcareous loam about 9 inches thick. The underlying material is light brownish0gray loam and very fine sandy loam.

Nearly all areas of Penoyer soils have been cleared and are planted to crops. The soils are used mainly for alfalfa, small grains, corn, sugar beets, melons, and irrigated pasture. Where air drainage is favorable for reducing the frost hazard, these soils are used for apple orchards.

Penoyer loam, 1 to 3 percent slopes (PeB). - The profile of this soil is the one described as typical of the series. The subsoil is typically loam or very fine sandy loam. Below a depth of 40 inches, this soil is weakly stratified with clay loam to sandy loam. In places gypsum veining and olive colors are below a depth of 3 to 4 feet.

Drainage is good, and permeability is moderate. Roots penetrate deeply. This soil retains about 12 inches of water, but only about 5 inches of water is readily available to plants. Runoff is medium, and the susceptibility to erosion is moderate. This soil is easy to work and to irrigate. It has the highest natural fertility of any soil in the survey area, and it is most responsive to management. Land leveling is needed in a few areas. The frost-free season is 110 to 130 days in 3 out of 4 years.

This soil is used for spring and fall range and for irrigated pasture, alfalfa, small grains, corn, and sugar beets. Because of the short growing season, alfalfa produces only two full crops and sometimes part of a third crop each year. Corn does not mature for grain and is used for ensilage.

The Ravola series consists of soils that are deep, medium textured, moderately permeable, and well drained. These soils occupy moderate to large areas of alluvial valleys. They have formed in alluvium that washed from shale and sandstone. The vegetation is mainly galletagrass, shadscale, and some greasewood. Elevations range from 4,000 to 6,500 feet. The annual rainfall is 6 to 11 inches, and the mean annual soil temperature is 47° to 54° F. The frost-free season is 110 to 160 days.

In a typical profile, the surface layer is light brownish-gray, slightly hard, moderately calcareous loam about 9 inches thick. The underlying material is light brownish-gray, moderately strong calcareous loam that in places is weakly stratified with layers of sandy loam or clay loam.

Nearly all areas have been cleared and are used for irrigated pasture, alfalfa, small grains, and corn. Some areas in the mouths of canyons, where air drainage is good enough to reduce the hazard of frost, are used for apple and peach orchards. Areas not cultivated are used for range.

Ravola loam, 1 to 3 percent slopes (RlB). – In most places the profile of this soil is like the one described as typical of the series. In some places, however, the texture between depths of 10 to 40 inches is silt loam to very fine sandy loam and the texture below 40 inches is sandy loam to silty clay loam. Salinity generally is slight to moderate. Alkalinity ranges from none to moderate. Veins of gypsum are common below a depth of 20 to 30 inches. The frost free season is 110 to 130 days in 3 out of 4 years.

Included in mapping were areas of Billings silty clay loam, and other areas ½ acre to 1 acre in extent, of poorly drained, strongly or very strongly saline-alkali soils. Also included were areas of a soil that is brown or light olive in color, and areas of Ravola loam in which the slopes are slightly less than 1 percent.

Drainage is good and permeability is moderate. Runoff is medium, and the susceptibility to erosion is moderate. Roots penetrate to a depth of 5 feet or more. This soil retains about 10.5 inches of water, but only about 6 inches of water is readily available to plants. Natural fertility is low, but the fertility in many fields is high because fertilizer has been applied. This soil is easy to work and to irrigate. The uniform distribution of irrigation water is needed. Land leveling can be done with little or no damage to the soil.

This soil is used for spring and fall range and for irrigated pasture, alfalfa, small grains, corn, and sugar beets. The growing season is long enough for alfalfa to produce two full cuttings and part of a third. Corn does not mature for grain and is used for ensilage.

Ravola silty clay loam, 1 to 3 percent slopes (RtB) - This soil has a surface layer of silty clay loam 8 to 15 inches thick, and it is gravelly in a few places. Otherwise, it is similar to Ravola loam, 1 to 3 percent slopes.

The infiltration rate is moderate to slow. This soil is fairly hard to work. A seedbed is more easily prepared if the soil is plowed in fall when barely moist, and is allowed to remain rough over winter, than if it is plowed in spring. This soil compacts if it is trampled or cultivated when wet.

Soils of the Saltair series are deep, poorly drained, very strongly saline, moderately fine textured and nearly level to gently sloping. They occupy moderate to large areas on alluvial fans, on flood plains, and in narrow alluvial valleys. These soils have formed in alluvium derived from marine shale and sandstone. The vegetation is greasewood, saltgrass, and kochia, but bare surfaces are common. Elevations range from 4,000 to 6,500 feet. The annual rainfall is 6 to 11 inches, and the mean annual soil temperature is 47° to 54° F. The frost-free season is 110 to 160 days.

In a typical profile, the surface layer is light brownish-gray, strongly calcareous, very strongly saline silty clay loam about 7 inches thick. The underlying material is light brownish-gray and light-gray heavy silt loam that is very strongly saline in the upper part. Platy crusts of salt on the surface, underlain by layers of soft, granular material, are common. The content of salt is 2 percent or more within 20 inches of the surface.

This soil is used for range, but the quality of the forage is poor.

Saltair silty clay loam (Sa) - The profile of this soil is the one described as typical of the series. The surface layer is ¼ to ½ inch thick, and it has platy structure but typically breaks to granules that contain numerous crystals of salt. A loose granular layer ½ inch thick to 3 inches thick commonly lies below the salt crust. The content of salt typically is between 2 and 3 percent in the upper 20 inches of the profile. Included in mapping, however, were small areas of a soil in which the content of salt is between 1 and 2 percent. The water table occurs at depths of 6 to 60 inches but generally is at depths between 36 and 60 inches. Typically, mottles are less than 20 inches below the surface, but in places they are at a greater depth.

Drainage is poor, and permeability is slow. Roots generally are concentrated near the surface, but they penetrate to a depth of 5 feet. Runoff is slow, and the susceptibility to erosion is slight.

This soil is used for pasture, but the quality of the forage is poor.

Saltair silty clay loam, barren (Sb) – This soil has a profile similar to the one described as typical for the series, except that the crust of salt on the surface is ½ to 1 inch thick. The content of salt is considerably more than 2 percent. The surface generally is bare and only a few scattered greasewood plants survive. In some places dead stumps of greasewood are all that remain of plants that were killed by the high content of salt in this soil.

The Ferron series consists of deep, poorly drained medium textured soils that are calcareous and nearly level or gently sloping. These soils are on alluvial fans and flood plains and in the bottoms of narrow alluvial valleys. They have formed in alluviums that washed from alkaline marine shale and sandstone. The vegetation is mainly wiregrass, sedge, redtop grass, and saltgrass. Elevations range from 4,000 to 6500 feet. The annual rainfall is 6 to 11 inches, and the mean annual soil temperature us 47° to 54° F. The frost free season is 110 to 160 days.

In a typical profile, the surface layer is light brownish-gray, moderately calcareous, slightly hard silt loam about 3 inches thick. It contains considerable organic matter from grass roots. The underlying material is light brownish-gray loam of very fine sandy loam that in places contains thin layers of clay loam or sandy loam. Veins of gypsum are common.

The Ferron soils are mottled or gleyed at a depth of less than 20 inches. The water table is near the surface most of the year. These soils are used for wet meadow pasture.

Ferron silt loam (Fr) – The profile of this soil is the one described for the series.. This soil generally occurs in small, low areas that receive seepage water from canals or from irrigated areas higher on the slopes. It is typically mottled to the surface, but in places mottles occur at a depth below 20 inches. The surface layer is rich in organic matter and is moderately saline in places.

Included in the mapping were small areas of very strongly saline-alkali soils and small areas of soils in which the water table is at a moderate depth.

Drainage is poor, and permeability is moderate. Because of the high water table, most roots penetrate only to a depth of 30 inches or less. Runoff is slow, and the susceptibility to erosion is light. The large amount of organic matter in the surface layer contributes to fertility, but this soil is low in natural fertility. Pastures that are dry enough for the application of fertilizer respond well to nitrogen and phosphorus.

This soil is used for grazing. Livestock can graze some areas only in winter when the soil is frozen.

The Libbings series consists of poorly drained, moderately fine textured, very strongly saline, gently sloping soils that are moderately seep over shale. These soils are typically at the bases of slopes below the Chipeta and Persayo soils, in areas where irrigation water or seepage from canals causes salts to accumulate. They developed in residuum and in local alluvium derived from shale. The vegetation is mainly greasewood and saltgrass. Elevations range from 5,000 to 6,500 feet. The annual rainfall is 6 to 11 inches, and the mean annual soil temperature is between 47° and 54° F. The frost-free season is 110 to 130 days.

In a typical profile, the surface layer is platy or granular grayish-brown silty clay loam about 2 inches thick. The underlying material is light brownish-gray and gray silty clay loam to clay that extends to shale bedrock. Bedrock is at a depth of about 34 inches.

The Libbings soils are used only for range.

Libbings silty clay loam (0 to 3 percent slope) (Lb) – The profile of this soil is the one described as typical of the series. The surface layer is only ¼ to ½ inch thick. It has a platy structure but typically breaks to granules containing numerous crystals of salt. The layer over the shale contains numerous crystals of gypsum or salt, but in some places these crystals are not present.

Included in the mapping were minor areas in which shale is at a depth of more than 40 inches, and some areas in the shale is at a depth of 20 inches. Also included were some areas of saline soils that contain less than 2 percent salt.

Drainage is poor, and permeability is slow above the shale. Runoff is medium, and the soil is moderately susceptible to erosion. The water table is 10 to 30 inches below the surface, and is highest early in summer. Mottles occur in places. Water spreads horizontally on top of the shale and penetrates to a depth of only a few inches. In some places water moves freely between the plates of shale. Roots penetrate to the shale, and then they spread horizontally.

This soil is used for grazing.

Appendix B: <u>Manual "Feel" Method for Field Moisture Determination</u>

This method of determining soil moisture levels is fairly accurate when applied on medium textured soils (silt loams or silty clay loams). Table 2 and Table 3 set forth the interpretation of the visual examination or "feel" method. Soil moisture information throughout the soil root zone profile is necessary for evaluating overall moisture conditions. When using the visual examination method, soil samples should be taken with an auger or probe at 8", 16" and 24" depths. Samples should be taken at several locations in each field for the most reliable information.

There are three conditions of moisture in the soil. They are referred to as the basic soil moisture relations. They are saturation, field capacity and wilting range. Saturation is defined as the amount of water that can be held in the soil when all air space in that soil is completely occupied by water (conditions when free water can be found when boring into the soil). Field capacity is defined as the amount of water a soil will hold against drainage by gravity (capillary water). Wilting range is defined as the range between the moisture content in a soil when plants begin to wilt and that moisture content when plants permanently wilt.

Table 2 Practical Interpretation Chart for Soil Moisture
USDA – Soil Conservation Service

Percent of useful soil moisture remaining	FEEL OR APPEARANCE OF SOILS			
	Coarse	Light	Medium	Heavy
0	Dry, loose, single-grained flow through fingers.	Dry, loose, flows through fingers	Powder, dry, sometimes slightly crusted but easily breaks down into powdery condition.	Hard, baked, cracked, sometimes has loose crumbs on surface
50 or less	Still appears to be dry; will not form a ball with pressure*.	Still appears to be dry; will not form a ball*.	Somewhat crumbly but will hold together form pressure.	Somewhat pliable, will ball under pressure*.
50 to 75	Same as Coarse texture under 50 or less	Tends to ball under pressure but seldom will hold together	Forms a ball*, somewhat plastic; will sometimes slick slightly with pressure	Forms a ball; will ribbon out between thumb and forefinger.
75 to field capacity	Tends to stick together slightly, sometimes forms a very weak ball under pressure.	Forms weak ball, breaks easily, will not slick	Forms a ball and is very pliable; slicks readily if relatively high in clay.	Easily ribbons out between fingers; has a slick feeling.
At field capacity	Upon squeezing, no free water appears on soil but wet outline of ball is left on hand.	Same as coarse.	Same as coarse.	Same as coarse.
Above field capacity	Free water appears when soil is bounced in hand.	Free water will be released with kneading.	Can squeeze out free water.	Puddles and free water form on surface.

*Ball is formed by squeezing a handful of soil very firmly with fingers

Table 3 Soil Moisture and Appearance Relationship Chart

(This chart indicates approximate relationships between field capacity and wilting point)

Moisture Deficiency In./ft.	SOIL TEXTURE CLASSIFICATION Coarse (Loamy Sand)	Sandy (Sandy Loam)	Medium (Loam)	Fine (Clay Loam)
	(field capacity)	(field capacity)	(field capacity)	(field capacity)
.0	Leaves wet outline on hand when squeezed.	Appears very dark, leaves wet outline on hand, makes a short ribbon.	Appears very dark, leaves a wet outline on hand, will ribbon out about one inch.	Appears very dark, leaves slight moisture on hand when squeezed, will ribbon out about two inches.
.2	Appears moist makes a weak ball.			
.4	Appears slightly moist, sticks together slightly.	Quite dark color, makes a hard ball.	Dark color, forms a plastic ball, slicks when rubbed.	Dark color, will slick and ribbons easily.
.6		Fairly dark color, makes a good ball.	Quite dark, forms a hard ball.	Quite dark, will make thick ribbon, may slick when rubbed.
.8	Dry, loose, flows thru fingers. (wilting point)	Slightly dark color, makes a weak ball.	Fairly dark, forms weak ball.	
1.0		Lightly colored by moisture, will not ball.		Fairly dark, makes a good ball.
1.2		Very slight color due to moisture (wilting point)	Slightly dark, forms weak ball.	Will ball, small clods will flatten our rather than crumble.
1.4			Lightly colored small clods crumble fairly easily.	Slightly dark, clods crumble.
1.6			Slight color due to moisture, small clods are hard. (wilting point)	
1.8				Some darkness due to unavailable moisture. Clods are hard, cracked. (wilting point)
2.0				

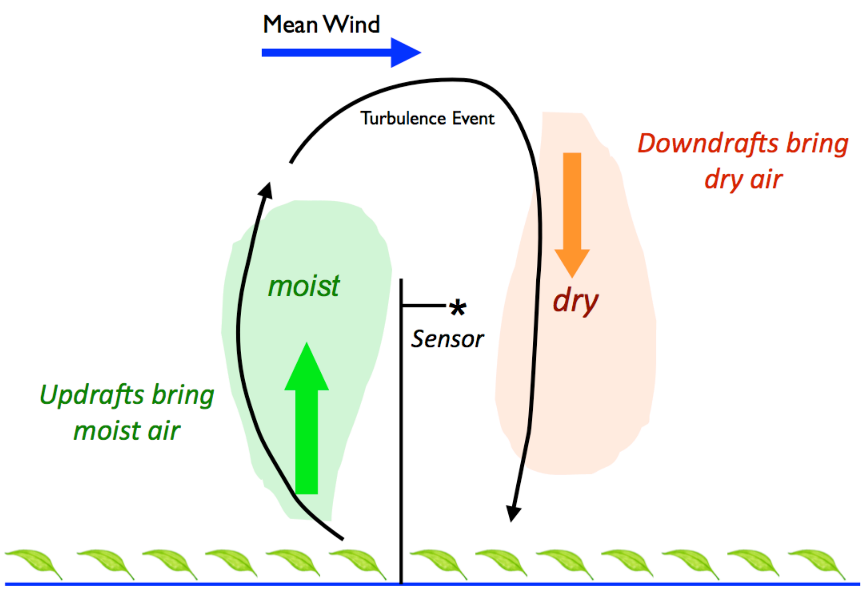
(McCulloch, 1976)

Appendix C: Actual Evapotranspiration (ET_a) Determination

Eddy covariance is the most direct way to measure the fluxes of mass and energy between the surface and atmosphere. Today, it constitutes the most scientifically credible and reliable method to determine various surface exchanges including evapotranspiration (ET) for a variety of different ecosystems (see for example: Baldocchi 2003; Aubinet et al., 2012). As such, it is the only methodology accepted for current research grade observation networks including: the CO_2 exchanges in terrestrial ecosystems (fluxnet.ornl.gov), the Integrated Land Ecosystem-Atmosphere Processes Study (http://www.ileaps.org), and the National Ecological Observation Network (http://www.neoninc.org).

Although the proper implementation and analyses involved in high quality eddy covariance calculations can be rather technical, the basic premise a fairly simple. It is turbulence in the lower atmosphere that actually transports properties of interest to and from the surface. Such a flow will exhibit episodes or gusts of upward motions and downward motions, at various time and space scales. If these updrafts and downdrafts are correlated with the property of interest, then they are acting to move it up or down.

An example would be the flux of water vapor from a vegetated surface (ET). As the air flows over a field, updrafts will be carrying moist air from near the surface, while downdrafts will bring down drier air from above. A simplistic, but useful diagram for this is illustrated below.



The vertical transport of humidity will be determined by how strongly the turbulence motions and the humidity correspond to one another. This is mathematically defined by the covariance determined over a proper averaging period. So the flux of water vapor or ET can be defined by:

$$E = cov\ (U_z\ , \rho_v)$$

where U_z is the vertical wind, ρ_v is water vapor density of the air, and cov is the covariance over the time period. Likewise, flux of CO_2 can be determined from:

$$F_c = cov\ (U_z\ , \rho_c)$$

Here, ρ_v is the CO_2 density of the air. So if measurements are made above a surface, as the wind blows the turbulence fluctuations past the sensors, this covariance can be measured. To capture the small-scale motions, a rapid sampling rate of 10 to 20 Hz (times per second) is required. In addition, the averaging period must be chosen to match the properties of the turbulence.

Implementation of the technique requires a 3-dimensional sonic anemometer, and a fast-response humidity/CO_2 sensor. It turns out that a suite of other corrections and analyses are also required, but are not discussed here.

Although considerable expertise is required for eddy covariance measurements and subsequent analyses, it represents the most scientifically credible method to estimate fluxes of mass and energy for a variety of surfaces. It remains the most credible methodology for cutting edge research into these processes.

Weather and evapotranspiration data are gathered automatically by the Farm's computer each night. Transmissions occur using cellular communication between 1:00 a.m. and 3:00 a.m. This modem is connected to a radio that calls the Hunter Research Farm evapotranspiration station. The data are transferred back to the office computer as an answer. These data are transferred to the ET consultants office in the early morning for daily quality control and processing. The office computer processes the data utilizing the Eddy Covariance equations and provides a daily and hourly weather summary for the ET station, as well as a monthly weather and ET summary for the station. The daily and hourly summary is available early in the morning for the coming day. This daily summary provides a single actual evapotranspiration (ET_a) value, measured in inches/day, for the previous 24 hour period.

During short periods when some sensors are not functioning properly, procedures developed in previous years are used to estimate the missing data required for computation of ET. For instance, missing global or net radiation data can be created using the linear relationship between these two parameters during the many years of data collected at the specific station.

The water balance equation and other equations required for computations of actual (ET_a, based upon the Eddy Covariance) and potential (ET_p) evapotranspiration.

The water balance at the surface (all terms in $mm \cdot time^{-1}$) is:

$$I + P = \pm LE \pm \Delta S \pm R \pm D \quad [A1]$$

where I is irrigation, P is precipitation, LE is positive for evapotranspiration and negative for deposition (dew or frost), ΔS change in the soil moisture content (positive for depletion and negative for repletion), R is surface runoff (positive when water goes out and negative when comes in), and D is deep percolation (positive when water leaves the root zone and negative when water comes to the root zone from underneath).

The energy balance at the surface (all terms in $W.m^{-2}$) is:

$$\pm R_n = \pm LE \pm H \pm G \quad [A2]$$

where R_n is net radiation, and LE(+ for evapotranspiration), H(+ for warming of the air), and G(+ for warming of the top soil) are latent, sensible and the top soil heat fluxes, respectively.

The Bowen-ratio, β is:

$$\beta = H / (LE) = C_p\, d\theta / (L\, dq) \quad [A3]$$

The potential temperature, θ, in K is:

$$\theta = T(1000 / P)^{0.286} \quad [A4]$$

The specific humidity, q, in $kg\ kg^{-1}$ is:

$$Q = 0.622\, e_a / (P - 0.378\, e_a) \quad [A5]$$

The actual vapor pressure, e_a, in mb is:

$$E_a = 6.1121 * EXP\, [17.502\, T_{dew}, °C / (240.97 + T_{dew}, °C)] \quad [A6]$$

The pressure, P, in mb is (assuming a dry adiabatic lapse rate of 10 °C/km):

$$P = 1013\, \{[288 - 0.01\, 9altitude, M)] / 288\}^{3.416} \quad [A7]$$

The latent (LE) and sensible (H) heat fluxes are:

$$LE = (R_n - G) / (1 + \beta) \quad [A8]$$

and

$$H = \beta\, (R_n - G) / (1 + \beta\,) = \beta\, LE \quad [A9]$$

The potential evapotranspiration, ET_p, in $MJ\ m^{-2}\ d^{-1}$ is:

$$ET_p = [\Delta / (\Delta + \gamma)](R_n - G) + 6.43\{[\, \gamma / (\, \Delta + \gamma\,)](\, e_s - e_a\,)(1.0 + 0.014u_2)\} \quad [A10]$$

Where R_n and G are in $MJ\ m^{-2}d^{-1}$, $e_s - e_a$ is in kPa (1 kPa = 10 mb), and u_2 is in $km\ d^{-1}$

The slope of saturation vapor pressure-temperature, Δ , in kPa °C^{-1} is:

$\Delta = 4098e_s$,kPa / (T,°C + 237.3)^2 [A11]

The saturation vapor pressure, e_s, in mb is:

E_s = 6.1121 * EXP[17.502 T,°C / (240.97 + T,°C)] [A12]

The psychrometric constant, γ, in kPa °C^{-1} as:

$\gamma = C_p$.P, kPa / (0.622L) [A13]

The latent heat of vaporization, L, in J kg^{-1} as:

L = 2500800 – 2366.8T,°C [A14]

The relative humidity, RH, in % is:

RH = 100(e_a / e_s) [A15]

Note:

The specific heat of air at constant temperature, C_p, is 1004 J kg^{-1}K^{-1}. Evapotranspiration, ET_a, in m d^{-1} can be computed using the computed latent heat (LE) in J m^{-2} d^{-2} divided by L p_v, where L is in J kg^{-1} and p_v = 1000 kg m^{-3} is the water density.

Aubinet, M., T. Vesala, D. Papale (Eds.). 2012. Eddy Covariance: A Practical Guide to Measurement and Data Analysis. *Springer Atmospheric Sciences*, Springer Verlag, 438 pp.

Baldocchi, D.D. 2003. Assessing the eddy covariance technique for evaluating carbon dioxide exchange rates of ecosystems: past, present and future. *Global Change Biology*, 9(4): 479-492.

Appendix D: Standard Nozzle Performance*

Nominal stream height 7' above nozzle** @ normal pressure

Nozz. Dia.	1/8"		9/64"		5/32"		11/64"	
Nozzle PSI	GPM	Dia. Ft.	GPM	Dia. Ft.	GPM	Dia. Ft.	GPM	Dia. Ft.
50	3.18	83	4.07	85	4.98	90	6.01	95
55	3.34	84	4.27	86	5.22	91	6.30	96
60	3.48	85	4.46	87	5.45	92	6.57	97
65	3.63	86	4.55	88	5.68	93	6.83	98
70	3.76	87	4.83	89	5.60	94	7.09	99
75	3.90	88	5.00	90	6.11	95	7.34	100
80	4.02	89	5.17	91	6.30	96	7.58	101

*All sprinklers were tested under minimum wind conditions. The water pressure readings were taken below the sprinkler inlet to provide meaningful design data. All pressure readings recorded are accurate to within 2% of actual pressure. The recorded flow rate (in U.S. gallons per minute) is accurate to within 1% of actual flow.

**Standard Nozzle at mid-point of pressure range

(Weather·Tec, 1999)

Appendix E: Sprinkler Line Identifying Names

Hunter Research Farm

Field Name	Abbreviation
East Farm	
Alfalfa East	EAE
Alfalfa Center	EAC
Alfalfa West	EAW
Pivot South	EPS
Pivot Center	EPC
Pivot North	EPN
Pump House	EHP
Lake South	ELS
Lake North	ELN
Lake West	ELW
West Farm	
Haul Road South	WHRS
Haul Road North	WHRN
Red Square West	WRSW
Red Square East	WRSE
Barley South	WBS
Barley Center	WBC
Barley North	WBN
Wheat	WW
Gibson	WG
Gibson Handline	WGHL
Perry's Triangle	WPT
Weather Tower	WTW
North Farm	
Cut North	NCN
Cut North Handline	NCNHL
Cut South	NCS
Cut South Handline	NCSHL
Maggie West	NMW
Maggie Center West	NMCW
Maggie Center	NMC
Maggie Center East	NMCE
Maggie East	NME
Dennison	ND
R-48	NR48

Appendix F: Sprinkler Head Count per Line

Hunter Research Farm Riser and Sprinkler Heads

LINE	Total Riser	1	2	3	4	5	6	7	8	9	10	11	12	13
EAE	12	13	13	13	13	9	9	9	9	9	9	8	8	
EAC	12	28	26	26	26	24	24	22	20	18	16	16	14	
EAW	12	28	28	28	26	26	26	25	25	25	25	25	25	
EPH	8	25	26	26	25	23	22	20	19					
EPS	9	35	35	35	35	33	33	29	27	23				
EPC	10	36	36	36	36	36	30	30	30	30	30			
EPN	7	28	28	28	28	26	24	22						
WHRN	7	28	28	28	28	28	28	28						
WHRS	8	28	28	28	28	28	28	28	28					
WRSE	5	20	20	20	20	20								
WRSW	6	21	21	21	21	21	21							
WBS	7	37	37	37	37	37	37	37						
WBC	7	32	32	32	32	32	32	29						
WBN	7	20	20	20	20	20	19	17						
WW	9	19	19	19	19	19	19	19	19	19				
WG	12	19	19	19	19	19	19	19	19	19	15	13	9	
WGHL	7	8	7	6	5	4	3	2						
NCN	7	35	35	33	31	30	28	26						
NCNHL	7	4	4	4	4	4	4	4						
NCS	9	32	32	32	32	30	29	28	22	20				
NCSHL	4	18	16	5	5									
NMW	10	46	46	46	46	46	46	46	46	46	46			
NMCW	11	39	39	39	39	39	39	39	39	39	39	39		
NMC	11	36	36	36	36	36	36	36	36	36	34	34		
NMCE	10	30	30	30	30	30	30	30	30	30	30			
NME	11	29	29	29	29	29	29	29	29	29	29	29		
ND	10	48	48	48	48	48	48	48	48	48	48			
NR48	7	43	43	43	43	43	35	35						
ELW	10	32	32	32	32	32	32	32	32	32	32			
ELN	8	39	39	39	39	39	39	39	39					
ELS	8	35	35	35	35	35	35	35	35					

Appendix G: Irrigation Record Sheet

Irrigation Set: Riser Location of Set

Hunter Research Farm 2005 Enter riser number of the sprinkler set into the portion of the cell for the date in use

Month - **Date-**

Description (name)			Mon -1	Mon -2	Mon-3	Tue-1	Tue-2	Tue-3	Wed-1	Wed-2	Wed-3	Thu-1	Thu-2	Thu-3	Fri-1	Fri-2	Fri-3	Sat-1	Sat-2	Sat-3
East Farm																				
Alfalfa East	EAE	12																		
Alfalfa Center	EAC	12																		
Alfalfa West	EAW	12																		
Pump House	EPH	8																		
Pivot South	EPS	9																		
Pivot Center	EPC	10																		
Pivot North	EPN	7																		
West Farm																				
Haul Road North	WHRN	7																		
Haul Road South	WHRS	8																		
Red Square East	WRSE	5																		
Red Square West	WRSW	6																		
Barley South	WBS	6																		
Barley Center	WBC	8																		
Barley North	WBN	7																		
Wheat	WW	9																		
Gibson	WG	12																		
Gibson Handline	WGHL	7																		
North Farm																				
Cut North	NCN	7																		
Cut North Handline	NCNHL	1																		
Cut South	NCS	9																		
Cut South Handline	NCSHL	4																		
Maggie West	NMW	10																		
Maggie Center West	NMCW	11																		
Maggie Center	NMC	11																		
Maggie Center East	NMCE	10																		
Maggie East	NME	11																		
Dennison	NDS	10																		
R-48	NR48	7																		
East Lake Farm																				
Lake West	ELW	10																		
Lake North	ELN	8																		
Lake South	ELS	8																		
Other Areas																				
Perry's Triangle	WPT																			
Weather Tower	WTW																			
System Pressure	psi																			
TDS - (weekly)	ppm																			
River sprinkler check, Days																				
River sprinkler check, Afternoons																				

Flow Meters Read Flow Meters and Depth to Water Monday Mornings

Big Pond		**Big Pond**		**Ft**	**In**
Old Pond West		**Old Pond**		**Ft**	**In**
Old Pond East		**Old Pond Ash Pile**			

Signature

Morning		/
Afternoon		/

Application rate and volume equations

Total volume of wastewater delivered per sprinkler head

$H_t = V_n * (60 * (T))$

Where
- H_t = Total volume delivered by sprinkler head in one set, gallons
- V_n = Water volume delivered for 5/32 inch nozzle, gallons per minute (gpm), equals **6.3** gpm
- T = Total time of sprinkler set, hours
- 60 = 60 minutes/hour

Total volume of wastewater delivered per sprinkler line

$V_t = S_n * H_t$

Where
- V_t = Total volume delivered by sprinkler line in one set, gallons
- S_n = number of sprinkler heads on line at riser set S
- H_t = Total volume delivered by sprinkler head in one set, gallons

Total area sprinkler by one sprinkler head

$A_s = W_s * L_s$

Where
- A_s = Area sprinkled per sprinkler head, square feet (ft^2)
- W_s = Width of set, feet (ft), equals **60** ft
- L_s = Length of set, ft, (distance between heads) equals **40** ft

Total area sprinkled by one sprinkler line per set, square feet

$T_a = A_s * S_n * L_s$

Where
- T_a = Total area sprinkled by one sprinkler line, ft^2
- A_s = Area sprinkled per sprinkler head, square feet (ft^2)
- S_n = number of sprinkler heads on line at riser set S
- L_s = Length of set, ft, (distance between heads) equals **40** ft

Total area sprinkled by one sprinkler line per set, acre

$$T_{at} = \frac{T_a}{A_f}$$

Where
- T_{at} = Total area sprinkled per set, acre (ac)
- T_a = Total area sprinkled by one sprinkler line, ft^2
- A_f = Square feet per acre foot, equals **43,560** ft^2/ac

Total volume of wastewater delivered per sprinkler line, acre feet

$$AF_v = \frac{V_t}{V_{af}}$$

Where
- AF_v = Total volume applied per sprinkler line, acre feet (acft)
- V_t = Total volume delivered by sprinkler line in one set, gallons
- V_{af} = Gallons (gals) per acft, equals **325,827** gals/acft

Total water applied per acre, acre feet per acre (acft/ac)

$$T_{af} = \frac{AF_v}{T_{at}}$$

Where
- T_{af} = Total water applied per acre, acft/ac
- AF_v = Total volume applied per sprinkler line, acre feet (acft)
- T_{at} = Total area sprinkled per set, acre (ac)

Total Water Applied per acre, acre inches per acre (acin/ac)

$Tai = Taf * In$

Where
- Tai = Total water applied per acre, acin/ac
- T_{af} = Total water applied per acre, acft/ac
- In = inches per foot, equals **12**, in/ft

DWQ-2020-011427