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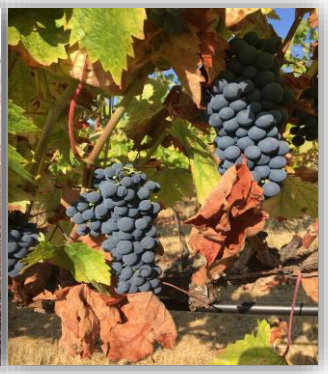

Irrigation and Scheduling Toolkit for Grapegrowers

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1.1 Maintaining and Evaluating Your Irrigation System

Evaluate your systems' performance regularly to ensure efficient delivery of water. Proper maintenance, along with making necessary repairs and upgrades can help most systems be 10-25% more efficient, sometimes more. This benefits your crop quality, reduces pumping and labor costs, and saves water.

Best Practices for Monitoring and Maintaining your System:

- **Monitor for leaks**. Walk your rows during irrigation sets and **promptly** repair any found. Examine a portion of your irrigation block every time you water so the entire block gets examined each month.
- **Maintain good water quality**.
  - Clean your filters regularly. Filters should not lose more than 5-7 psi pressure while irrigating. Manually clean before losing 5 psi, or install an auto backflush systems using timed intervals and pressure differentials to initiate cleaning.
  - Flush the ends of your hoses at the beginning and end of each irrigation season, and more if your system has a lot of sediment in it.
    Catch sediment coming out of a hose to understand what might clog emitters in the system. Hose lines should run clear between 1-3 seconds. Flush hoses more often if it regularly takes more than a few seconds.

- **Ensure good emitter operation.**
  - **Use pressure compensating emitters**. They are key to maintaining consistent flow rate for irrigation and delivering nutrients through fertigation, especially on hillsides. They are essential for creating good **distribution uniformity (DU).**
  - **Maintain good operating pressure.** Your system should run between 8-50 psi, and more ideally 10-45 psi. Pressure compensating emitters diverge from manufacturer specified flow rates at higher and lower pressures. High pressure can wear down the diaphragms in the emitters and cause system blowouts and leaks. Install gauges at the manifolds to monitor pressure.
  - **Replace old, dysfunctional, and plugged emitters.** Check emitters at the beginning and during the season. When necessary, replace with *the same type and flow rate of PC emitter.* Emitters are rated to last 10 years, but can last longer in our coastal climate. Older emitters and areas that plug more frequently need to be checked more often.

1.2 Test Pressure in Your System

Measure pressures while the irrigation block is operating as it normally does each irrigation set. For instance, if you normally irrigate Block 1 and 2 together, do the test while both blocks are on. Don't just test block 1 by itself.

Use a Pressure gauge with a pitot tube attachment. Oil filled pressure gauges work the best. Pitot tubes can be purchased from your irrigation supply vendor. Use a hole punch to puncture the poly tube

while it is fully pressurized. Insert the pitot tube in the poly line, read the pressure, and place a goof plug in the hose after taking the reading. Test 12 lines evenly spread throughout the irrigation block, taking readings near the ends and in the middle of each line. Avoid testing the outer lines of the block. In flat blocks, less readings are necessary if similar pressure is found at the corners. On hillside blocks, more readings are necessary and you may wish to focus more readings in areas of concern. Write down each pressure reading and make a pressure map to help you visually see and understand the pressure in your irrigation block.

1.3 Test Flow Rates

Place catch cans (wide quart size Tupperware style containers) under emitters for 4 or 5 minutes during irrigation sets to measure flow rate consistency. Test 36-60 emitters (total needs to be a multiple of 4) evenly spread throughout the irrigation block. Make sure all flow tests are for the same amount of time. Avoid testing the lines on the ends for best results. Collect all water that comes out from the emitter, and measure with a graduated cylinder. Write down all flow rates, and divide the average of the lowest 25 % of flows by the average of all measurements taken. The result is your distribution uniformity (DU). Ideally it is in the mid 80's or higher. Low DU indicates the need to make system improvements or clean your filter more often.

If emitter plugging occurs in some but not all portions of your vineyard, do 36-60 total emitter flow tests, where consecutive emitters are tested in 3 (or more) areas. Make sure to test an area a) in the second or third row from the manifold where water enters the block b) in the second or third row furthest from the manifold c) in the middle of the block. Block DU can be determined in the same way as above. Compare flow rates of emitters in the same areas. If emitters regularly vary more than 15% from the average for that area, consider replacing them.

2.1 Evaluating Your Irrigation System

What to look for:

- Evaluate one irrigation block at a time, as it normally operates. Thus if you normally irrigate Block 1 and 3 in your vineyard simultaneously, then evaluate that as one irrigation block. Don't just test Block 1 or 3 alone, unless that is how you normally irrigate it.

- To run pressure tests, you will need a pitot tube, pressure gauge (oil filled is best), hole punch and goof plugs. The pressure gauge is screwed onto the pitot tube. Both these items are available through local irrigation supply vendors. For flow tests you will need up to 28 wide, quart sized tupperware style containers, and a 500 mL graduated cylinder.

2.2 Checking Pressure

- Monitor pressure at the irrigation block manifold or a poly line near the manifold for 2-4 hours, starting at the beginning of the test. Monitor in the same location for the entire time, the longer the better. Ideally there is a gauge installed in the system; if not, a pitot tube attached to a gauge can be inserted in the poly hose line near the manifold. Take readings at least once an hour. If pressure drops 5 psi or more, the filter needs cleaning, or other issues are impacting performance.
- Check pressure throughout the irrigation block.

***On flat blocks**:* check pressure at the four corners, and one or two places in the middle. Test one or two hose lines in, as pressure on the end lines can differ from the rest of the block and provide less representative information. Poke a hole in the poly line with a hole punch, insert the pitot tube, and take your reading with the gauge held as horizontally as is possible.

Insert the goof plug in the hole when finished. If all the pressures are in a similar range (within 5 psi of each other), no further pressure tests should be necessary. Make a map of your readings. Pressures should fall within 8-50 psi, more ideally 10-45 psi. If higher or lower, make adjustments to your system where needed until within that range.

If your pressure ranges more than 5 psi, follow the instructions below for sloped blocks.

***For sloped irrigation blocks**:* Map out your block, designating 12 lines for testing, spread more or less evenly throughout your irrigation block. Avoid the end hose lines, starting the second or third line in. If risers are at the end, take 3 readings per line, with two of those being 3-5 vines in from each end of the hose, and one in the middle of the hose. If rows are long or you have substantial slopes or areas of concern, you may wish to take more readings. If risers are in the middle of the hose line, taking 3 readings, as above, is fine in shorter rows, but its best to take two additional readings on longer rows. Take one reading between the middle and end on each side, along with the three other readings. Map out your readings as you go. Once you have taken the 36-60 readings, create a cleaner map back in the office as soon as possible. Focused review of this map will help you see how pressure operates throughout the block, and helps you to make determinations if action needs to be taken to increase, decrease, or regulate pressure anywhere in the block.

If the irrigation block is actually two or more vineyard management blocks, still test a total of 12 lines evenly spread throughout the one larger irrigation block.

2.3 Testing Flow Rates

- While the system is operating during a normal irrigation event, use catch cans (wide, quart sized tupperware type containers) to measure flows. If you have good water quality and no plugging issues, test flows in 36-60 places, evenly spread throughout the vineyard. The total number of flow test needs to be a multiple of 4 to determine your **distribution uniformity (DU).** Each test needs to run for 4 minutes. Take a pressure reading where the flow is measured to ensure you are testing in an area realistically reflecting your block's performance. Write down the pressure. Place the catch can directly under the emitter to catch all water coming out during the test. You may need to clear weeds or flatten the area before starting the test for the catch can to receive all the water from the emitter and not fall over. Don't test when it is too windy. If the emitter is spraying water in a way that all water can't be caught, skip that emitter. **All flow tests must be for the same number of minutes**. Use a graduated cylinder to measure the flow rate. Write down the flow rate for all flows measured. Divide the average flow of the emitters delivering the lowest 25% of flows by the average flow of all emitters tested. This number is your **Distribution Uniformity (DU)**. It is important to aim for .85 DU or higher. Systems rarely go higher than .94 DU.

- If you have water quality issues or emitter plugging, modify your testing to test consecutive emitters in several places. Once again, test 36-60 emitters total, with a higher number providing better results. For instance you could test 6 consecutive emitters in 10 places evenly spread throughout the irrigation block. The Cal Poly protocol tests in 3 places: 16 consecutive near the manifold (one line in), 16 consecutive emitters in the middle of the field, and 28 consecutive in the second or third line from the end, furthest from the manifold. 28 are tested near the end as the protocol is designed for large blocks (around 80 acres), where sediment build up and plugging is greatest toward the end of the system.

Group your flow tests in a manner you think will best reflect your systems' actual performance. If you have plugging, some catch cans need to be placed under emitters with plugging issues to reflect that in your DU computation.

If consecutive emitters in one area regularly vary more than 15% from the average flow rate for that area (or other areas), you need to consider replacing those emitters for better DU.

2.4 Testing for Pressure Compensating Function

- Pressure compensating (PC) emitters should deliver similar amounts of water if operating in the 8-50 psi range. As many systems fluctuate in pressure, 12-45 psi is a better range, with anything 15-30 psi being ideal. PC emitters are rated to last 10 years, though they can last longer in our coastal climate. If you have older emitters or observe varying flow rates and emitter delivery patterns, you might wish to do a PC emitter test.

  PC Test: Measure 10-20 consecutive emitters in an area with the highest operating pressure in your vineyard. This can be determined doing the flow testing described above. After catching flows for 4 minutes, measure the total amount delivered to all catch cans in that area. Write down the pressure and total volume collected from all catch cans. Using the hose riser valve or a ½" poly valve inserted into the hose line tested (near the gauge), adjust the valve to around 4-5 psi. Repeat the test using the same set of emitters for the exact same amount of time. Write down the pressure and volume collected. Adjusting the pressure to an exact psi can be very challenging in some systems, so it is best to work with two people, one reading the gauge, while the other adjusts the valve. Adjust the pressure to 8-9 psi and repeat the test on the same emitters for the same amount of time. Repeat at 2 intervals between the 8-9 psi level and the highest operating pressure you started with. If your pressure is low, you may not be able to do all tests, or test PC function at all. Write down all pressures and flows. To save time, you can test an area where you already measured individual emitter rates, as long as you test at least 10 emitters, and test the exact same set of emitters for flow rates at each pressure.

  Once back in the office, graph the flows using a spreadsheet chart or other means. A normal system will show flow rates rising from the lowest reading until it peaks around 7-12 psi. It should then lower a bit and roughly level off until around 50

psi. After 50 psi, you will often see the flow rate increase again, though occasionally it will lower, as the diaphragms in the emitters stop functioning as designed. Sometimes you will see flow rates vary before 50 psi, which indicates the PC function is not working. Some systems will start delivering manufacturer specified rates at lower pressures, but most systems follow the general curve above. If you are not operating near PC designed rates, adjust your pressure if that is an issue, and/or replace old and dysfunctional emitters to even out your flow rates.

2.5 Other Tests and Items to Observe

- ***Leaks:*** While the system is operating, look for leaks at the irrigation block manifolds, filters, on the lines, risers, at all fitting junctions, emitters, and at the ends. Inspect on a regular basis. Promptly fix any issues.

- ***Water quality:*** flush the ends of the hoses. Test 3-7 hoses throughout your irrigation block. Time how long it takes for water to run clear, sediment to stop coming out, or for the water to consistently come out one color without sediment pulses. Catch water coming out of the hose with a nylon sock or other porous item to see what type of material is in the system. If it takes longer than 3-7 seconds to run clear or stop pulses of sediment, you need to a) clean filters more regularly b) flush your hoses more often, or c) both. For systems with water quality issues, it is best to test your water every three years by sending a sample to a lab that can test agricultural irrigation water.

- ***Emitters:*** how many emitters are there per vine? Are they PC? There should be the same number per vine, with the same type/flow rate everywhere in the block, unless a specific area purposely receives a different volume due to vine age or vigor. Emitters should be facing down to avoid water running down the line and away from the intended target in low pressure situations.

- ***Sags:*** are there significant sags in the line that might cause water to flow away from intended target in low pressure areas?

- ***Hose screens:*** Unscrew fittings connecting risers to poly lines. Check for hose screens. Remove and replace with a gasket if hose screens are present. This type of screen can cause significant line to line flow variation and reduce pressure. Let your block or primary filter do this work.

- ***Drainage after shut:*** Observe your system after it shuts off on slopes. Look for areas where water continues to emit for 15-60 minutes after the valve is shut off. What percentage of emitters in the block are still delivering water after 20 minutes? If you see too much vigor in these areas, these areas need to be addressed by inserting a ½" poly valve upstream of the area of concern.

- ***Pump/Filter stations:*** Look for the type of filter, auto back flush systems, pressure regulators and sustainers, and gauges. Install gauges and replace broken gauges to be able to monitor filter performance. Is there a big pressure difference before and after pressure regulators and filters? Is the valve throttled? Is there a meter? Use pressure regulators where necessary to maintain 8-50 psi in the field. Meters are recommended to understand and monitor your system, know how much water you are using, and see if you are using more or less water over time. Valve throttling is not recommended as it is difficult to repeat the same flow rate every irrigation event.

- ***Manifolds:*** How many do you have? Is there a filter, pressure regulators, pressure gauges? Does everything work? Is the valve throttled?

- ***Hoselines***: is there a pressure regulator on the line?

- ***Water source:*** Are you using groundwater, recycled water, water from a pond? Each has its own advantages and set of issues.

3.1 Tools to Improve Irrigation Scheduling

Do you want to grow quality grapes using the least amount of water possible? If yes, use scheduling tools to optimize your water use efficiency. Make plans for next growing season now. Several tools are available to achieve this. Some help to delay the onset of irrigation, and others are useful during the growing season. The following is a list of devices and methods is available to you:

- **Visual Observation**- Monitor the stage of shoot growth to determine when to start irrigating in spring or summer. Shoot tips should be slowing or stop growing before you initiate irrigation. http://advancedvit.com/wp-content/uploads/2017/04/Shoot_tip_indicators_2014a.pdf

- **Soil Moisture Sensors**-There are a variety of soil moisture probes available to growers to monitor conditions in the ground and inform you that it is time to irrigate. They vary in type of technology, sophistication, cost, and ease of use.

- **Plant Stress Monitoring**

    - Pressure Chamber-Measures sap flow tension within petioles.
    - Porometer-Measures stomatal conductance, which tells us how much oxygen and carbon dioxide is moving in and out of the leaves.
    - Sap Flow Sensors-External collars that convey information on vine transpiration.

- **Evaporation Transpiration (ET)**

    - CIMIS Stations- The state runs a network of stations measuring ET. Locate the one nearest you for daily data.
    - Actual ET-new technology and services are available to measure ET in your vineyard.
    - Weather Stations-Several companies offer units that provide rough ET and other pertinent weather data to help with irrigation decisions.

- **Timers and Controllers**- A wide array of units are available to execute more precise irrigation, and turn the system on and off at the right time, automatically.

- **Ariel Imagery**- Several companies provide this type of mapping service in our area. These maps help to define areas with different vigor and growing characteristics, and can be useful for defining logical irrigation and management blocks when replanting and redesigning vineyards.

4.1 Tools for Optimizing Irrigation Scheduling

Growers need to deliver enough water to meet essential crop water needs, while avoiding the application of water beyond that. Over watering causes water to run off, evaporate, or percolate past the root zone, where it is of no use to your crop. Excessive water use also burdens the grower with unnecessary expenses for pumping, while increasing greenhouse gas emissions. Fortunately there are a number of tools available to maximize the efficiency of timing and volume of water delivered. These tools can be used to delay the onset of irrigation early in the season (particularly with grapes), and to reduce the amount of water delivered once irrigation has been initiated.

To delay the start of irrigation, grape growers can use visual observations of the vines to determine when to start irrigating or hold off. Shoot tips that are slowing down or have stopped growing indicate the time to commence irrigation, unless you are able to dry farm. The stage of shoot growth that determines the best time to start watering depends on several factors including soil type, whether you are on a hill or down in the valley, and the amount of evapotranspiration at your site. Experience and past documentation on what has worked further informs this decision. To help with this, Advanced Viticulture Inc. provides a useful set of photos to determine the stage of shoot growth. It and other relevant resources can be found at: www.advancedvit.com/Shoot_tip_indicators_2014a.pdf.

There are several types of plant and soil moisture monitoring devices that can help you make the decision to start irrigating or hold off. Soil moisture monitoring probes can provide useful information to all types of growers. There is a wide range of devices that can be employed that range in price and ease of use. Probes can be inserted at the depth you want, and measure soil moisture content in different ways (i.e. some measure water volume, others tension or conductivity). Growers have used these devices for many years. They are more effective where the soil is more uniform. Knowing how to properly install and maintain the probes is critical for their effectiveness. Probes can be read manually or wirelessly. Data loggers can make them more useful by creating greater sets of information. With some systems, wireless data can be streamed directly to your computer or smart phone. Software is available to help log the data and interpret thresholds of when to irrigate.

Porometers and pressure chambers are useful for measuring plant water stress. Porometers measure stomatal conductance, which reflects how stressed a plant is as the stomata open and close to regulate oxygen and carbon dioxide movement under different conditions. They are becoming more widely used. The pressure chamber (often called a pressure bomb) takes midday readings of

sap flow in the petioles, which also reflects plant water stress. By looking at the shoot tips, in conjunction with using porometers, pressure chambers, and soil probes, growers can make more informed decisions on when to start irrigating.

These devices continue to be useful during the irrigation season. Some growers use one, all or a combination of these devices to know what the actual conditions are at the soil and plant level. While many growers irrigate based on the weather, habit, or feeling, the monitoring devices help us to determine when it is actually time to water. Through observations and experience, thresholds for these measurements can be established to make the decision to irrigate, which correlates with the data from monitoring.

Weather stations offer a further tool once irrigations have begun. They help us determine the evapotranspiration value (ET), which tells us how much water has moved out of the soil and plants, and needs replacement. Growers can use their own stations, use information from their neighbors', or look at nearby CIMIS stations for the reference ET. Using regulated deficit irrigation and knowing the percent of ET you want to aim for at different times of year, or stages of growth, ET can be very useful to scheduling irrigation. Surface renewal technology is a new approach growers are starting to use to determine on-site ET, irrigation timing and volume to deliver.

Wireless technology and dataloggers can be used to transmit the data of all these devices to growers to determine irrigation scheduling. Advanced systems may allow you to open valves remotely and/or automatically when grower determined thresholds are met. Using a combination of these tools, growers can often use 10-50% less water and meet their quality and quantitative production targets.

Once you have decided to irrigate, use controllers and timers to open and close valves. This ensures you deliver more precise amounts of water from set to set. This is important for conserving water and maintaining even crop production and quality from irrigation block to irrigation block. Using manually operated valves greatly increases the amount of times that we overwater, as irrigators get distracted with other tasks on the ranch or are late to return to the valve to turn it off. Some controllers have advanced features, like turning off the system when a leak is detected.

Take a trip to Wyatt Irrigation, Harmony Farm Supply or whoever supplies your irrigation equipment to better learn your options and the costs associated. Consider working with a professional that can assist you with your monitoring and provide specific times to turn on the water or hold off.