471 Industrial Ave, CA 95366
Phone: (209)599-6118 Fax: (209) 599-6119
sales@jackrabbitequipment.com www.jackrabbitequipment.com

Frost Protection Proposal for:

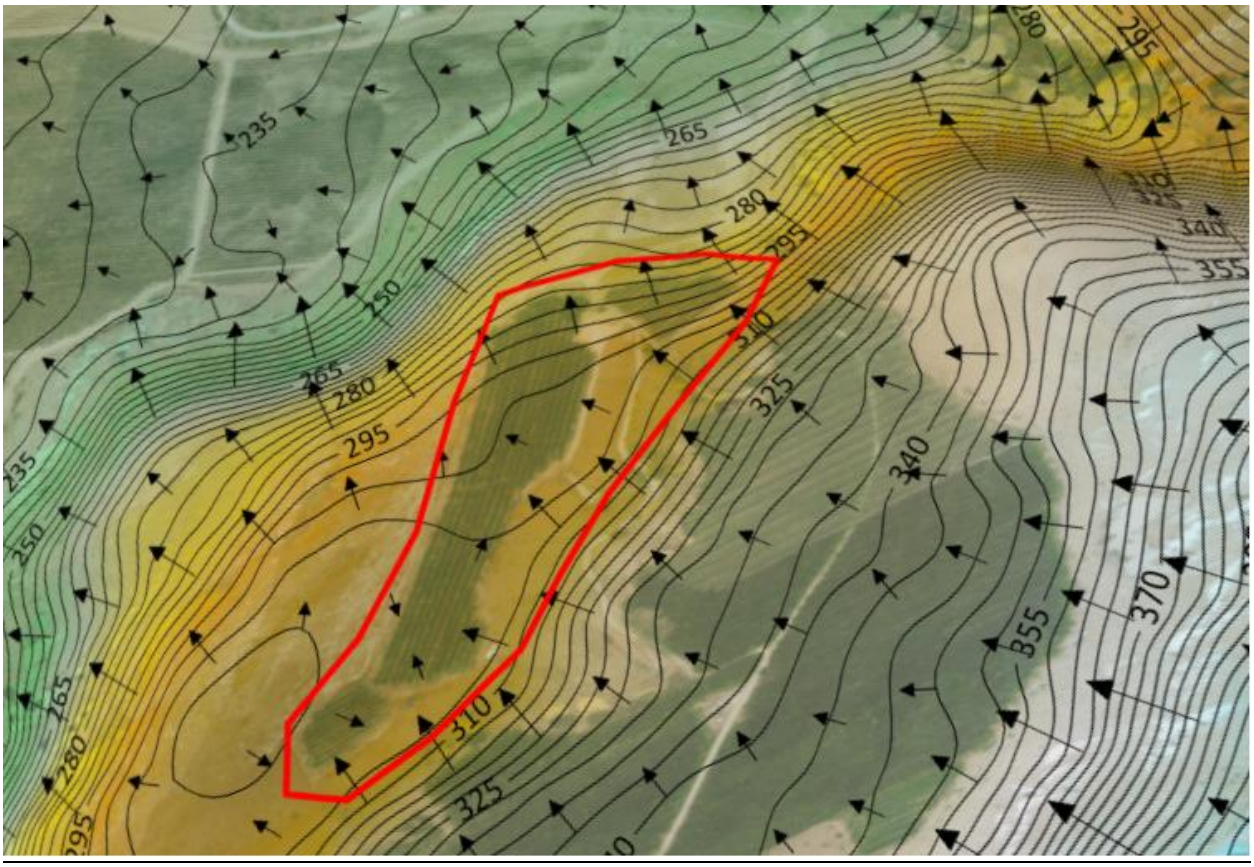
Information, data and drawings embodied in this proposal are strictly confidential. They are supplied with the understanding that they will be used only with Jackrabbit® products. Information may not be disclosed to third parties without the prior written consent of Jackrabbit®.

Prepared on Tuesday, May 09, 2023

Specifications

Crop:	Apple
Varieties	SugarBee
Total acreage:	3.32 acres (approx..)
Total acreage of damage:	3.32 acres
Cordon or skirt height:	NA
Soil type:	Supplee Ashy Very Fine Sandy Loam
Current frost protection method(s):	NA
Critical frost periods:	Winter
Frequency of frost events:	NA

This farm is located near Beebe, Washington with center point at
(Lat 47.843208) (Lon -119.941723).



Overview of Frost Damage

Under radiation conditions, clear skies and no wind, the ground will lose heat through long wave radiation. As the ground cools, it will also chill the air at ground level. The heavy, dense air stays close to the surface and the warm air rises, creating an inversion.

The colder, lower layers of dense air flow downhill until obstructed by a physical barrier or insufficient slope angle where it may accumulate and deepen. In general, it takes about 1-1.5% of slope for katabatic flow to take place.

Frost damage occurs mainly in areas where cold air accumulates. As more cold air flows into those areas, it continues to condense and get colder and deeper. When the cold air mass deepens enough to reach plant tissue, frost damage may occur.

Under radiation conditions, there are seven types of cold air accumulation. The following types have been identified as contributing to potential frost damage in your block.

Cold Air Lake:

Cold air lakes exist where a static mass of air builds up in a specific area, due to drainage obstructions or a low pocket. As cold air builds up, it displaces the warmer air. In the case of an obstruction, the cold air can build up to several times the height of the obstruction before spilling over. The lower the slope angle leading to the obstruction, the deeper the cold air can build up in relation to the height of the obstruction before finally flowing over. Low pockets accumulate air simply from lack of drainage.

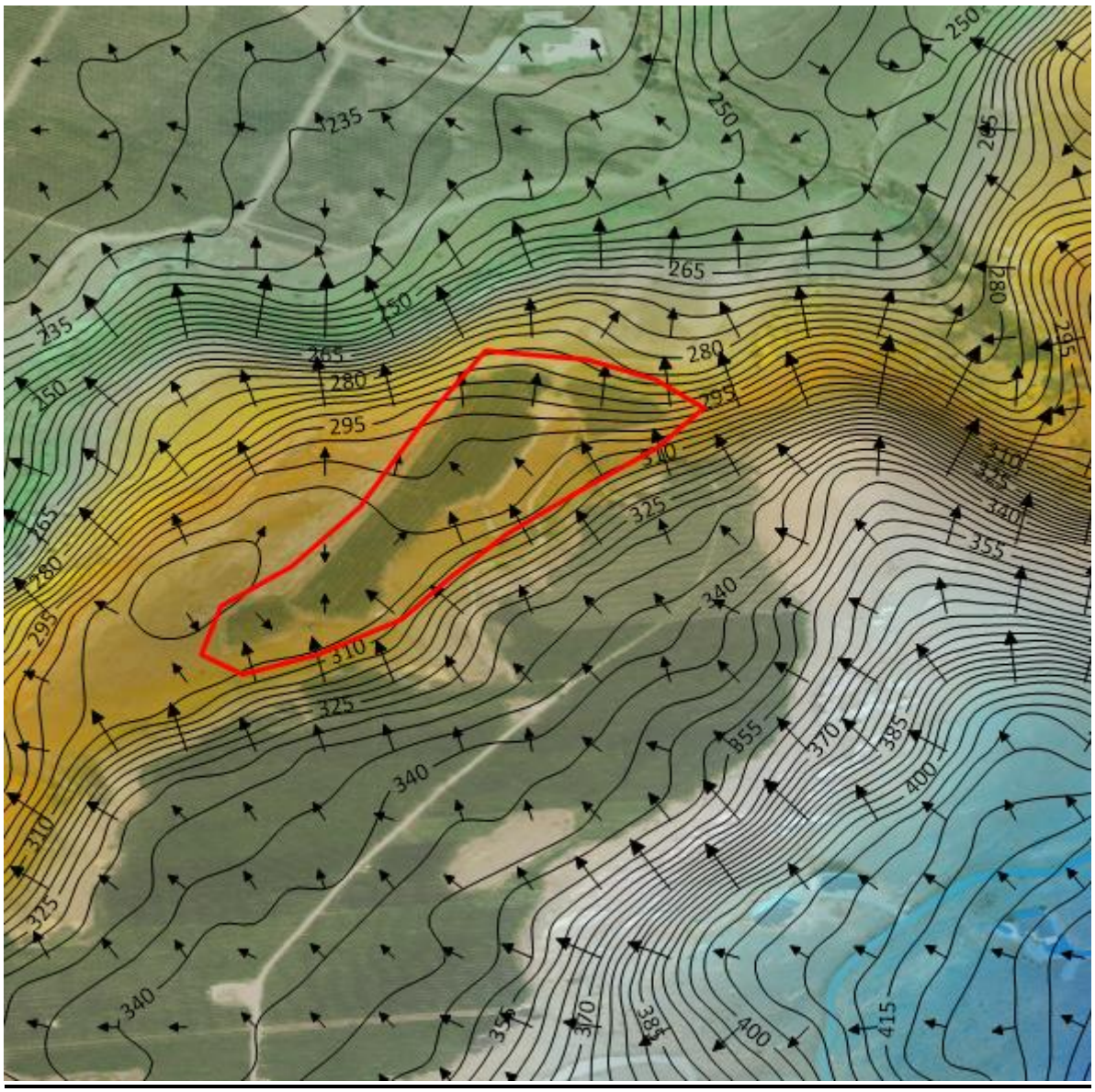
Cold Air Flooding:

Flooding occurs when the growing area itself has sufficient drainage, but the area below has insufficient drainage. When cold air fills the basin below the growing area, it can build up enough to flood back into the growing area.

The cold air accumulation pattern that is present is both a cold air lake and cold air flooding. Cold air flooding is occurring due to the mountain located on the right side of the field. Cold air is flooding down into the canyon and creating a cold air lake.

Note the longer the tail on the arrow, the greater the slope grade and katabatic flow (downhill air movement caused by gravity).

3 Meter Contour Interval Map



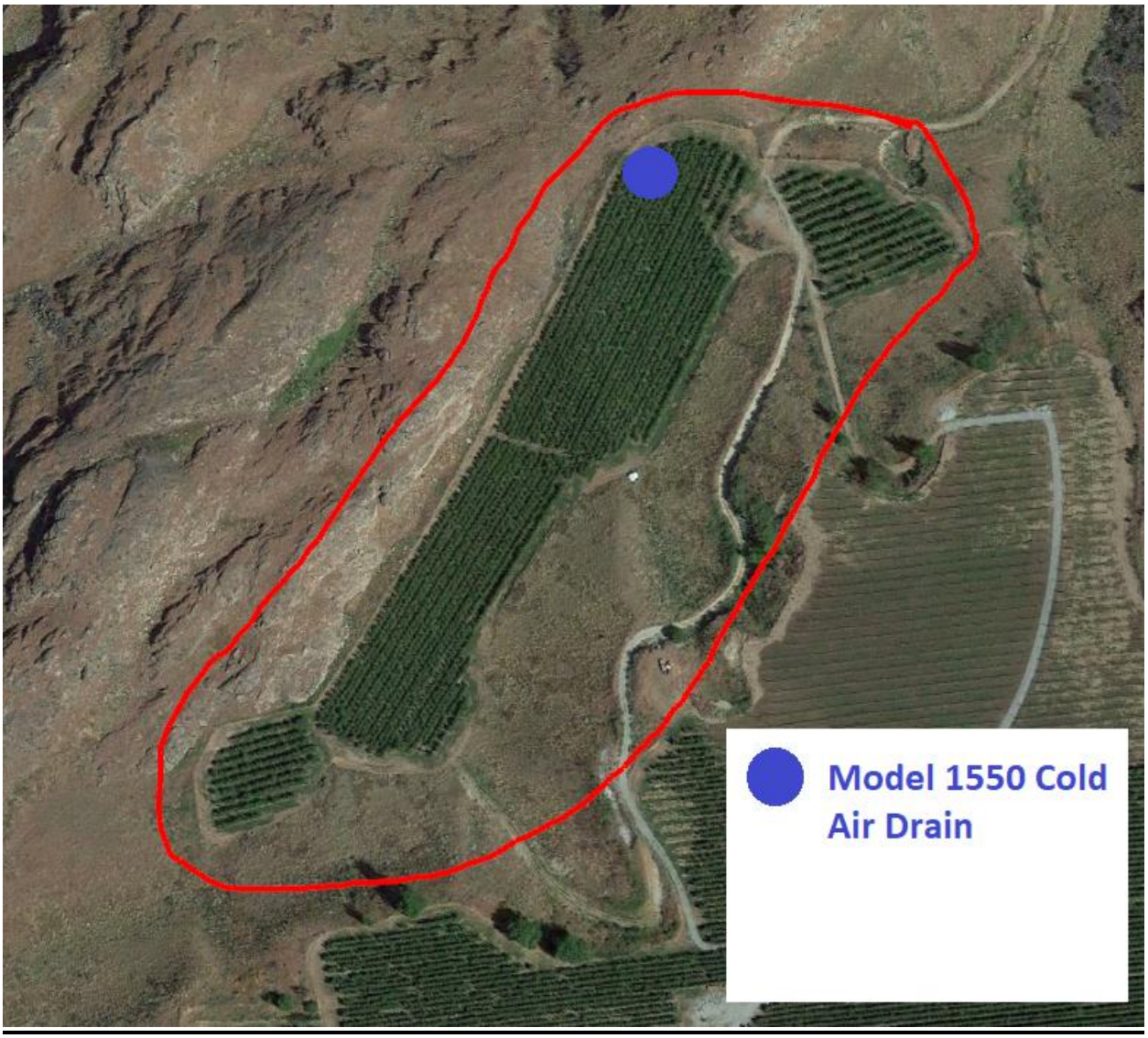
System Recommendation

Changes in the topography, vegetation or general circumstances of this area or in the adjoining or immediate areas can create circumstances under which this recommendation will no longer be valid. Please notify your Jackrabbit® representative for an updated evaluation when such changes occur.

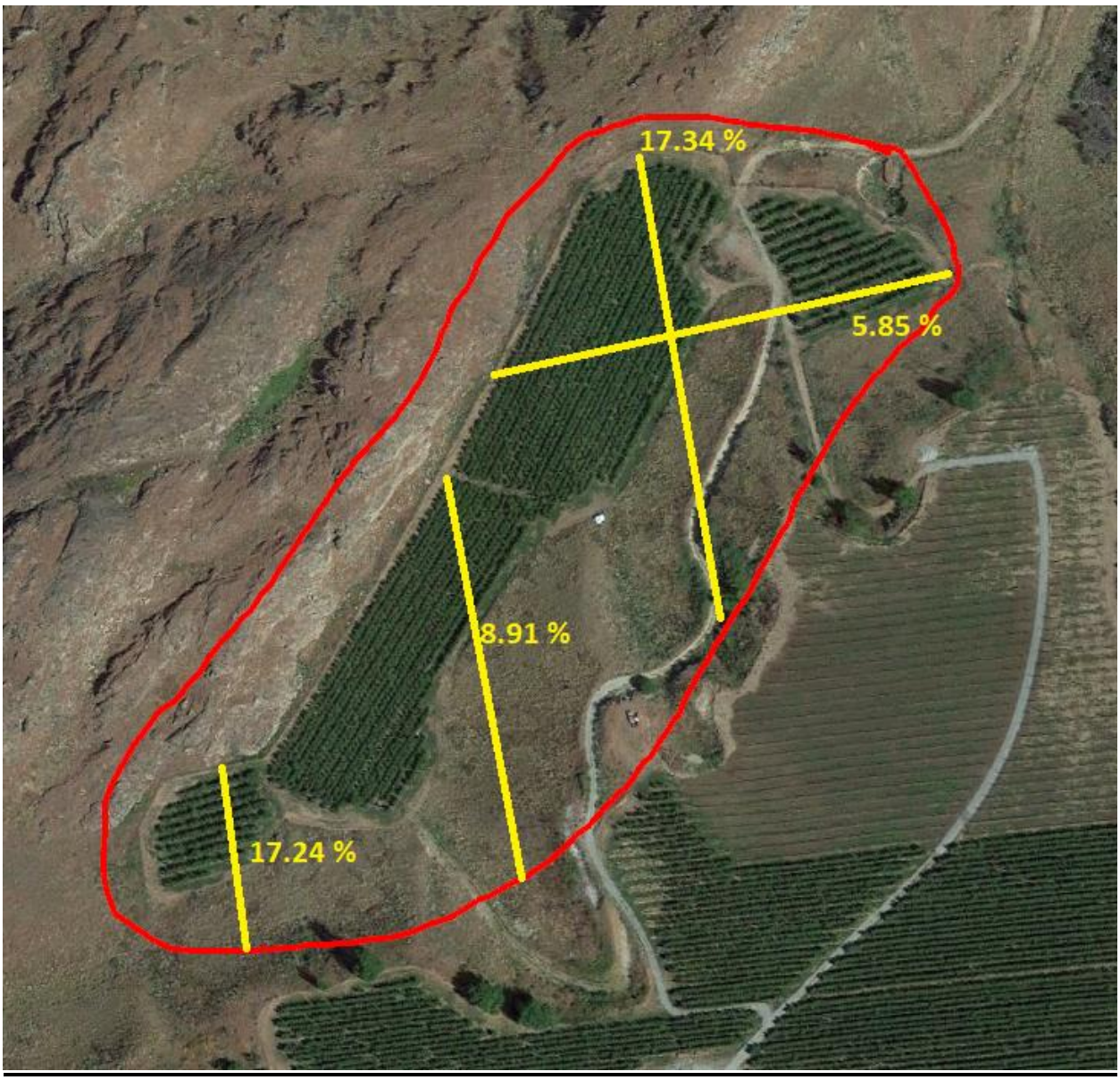
Maintain cover crop at 3 inches or less in height for better air flow.
Total Damaged Area- 3.32 acres

Quantity- 1 **Equipment- Model 1550 Cold Air Drain**

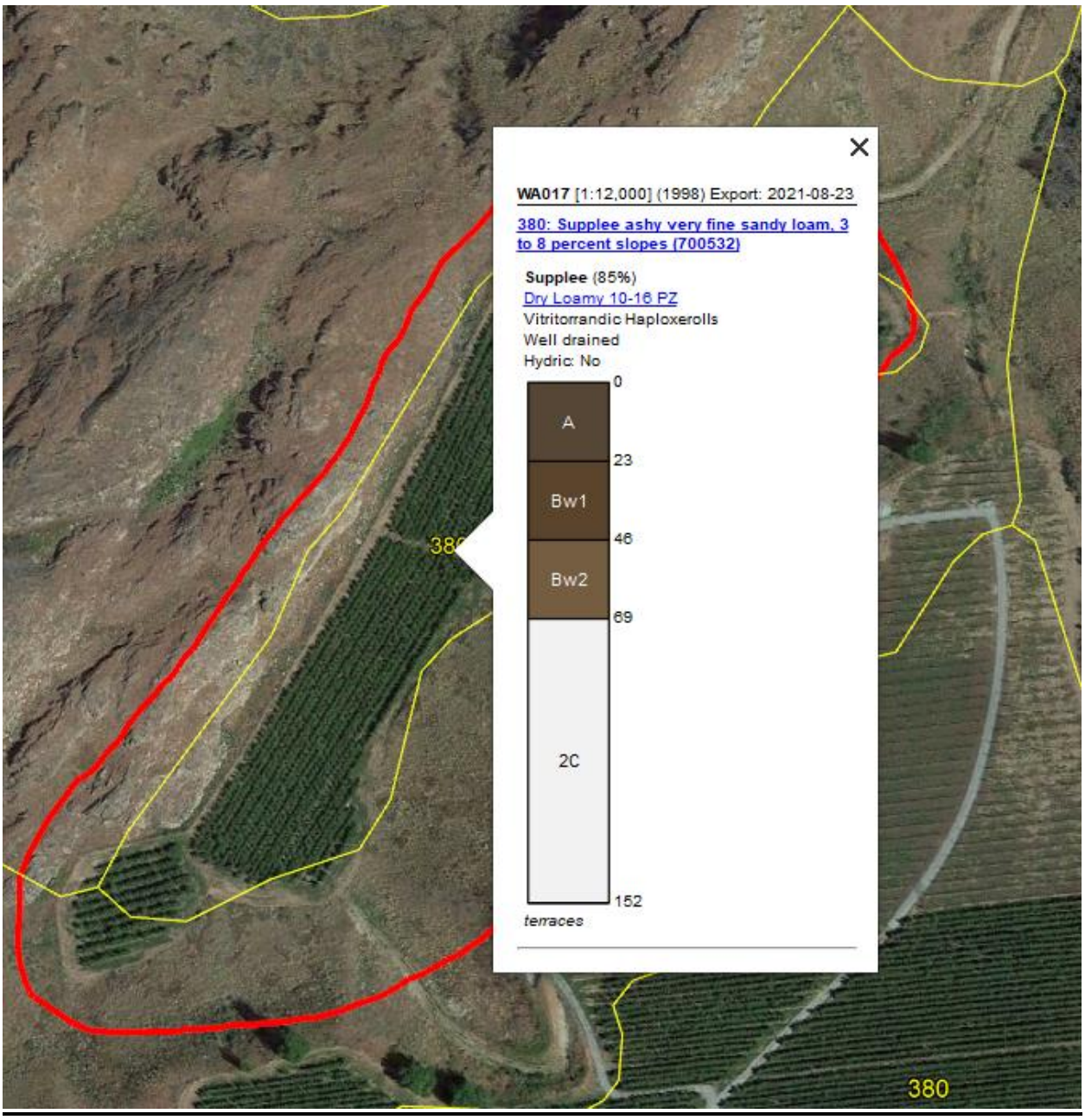
Placement



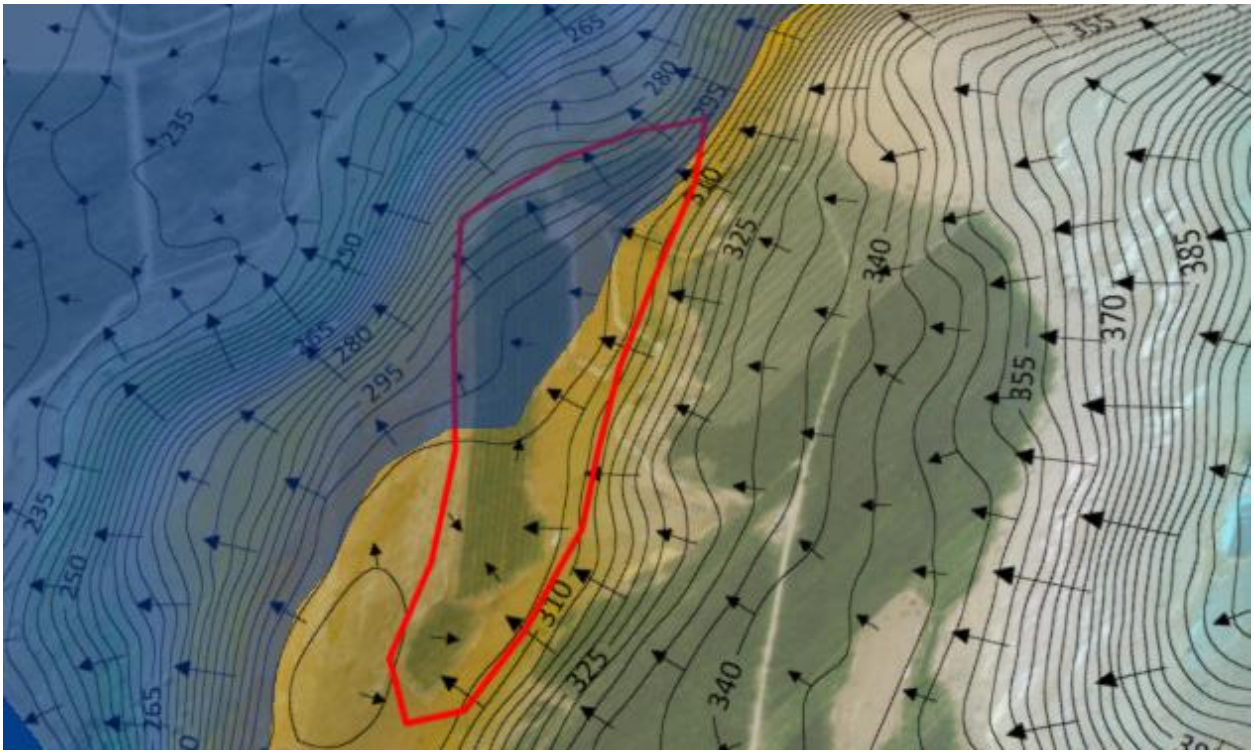
Slope Grade Percentages

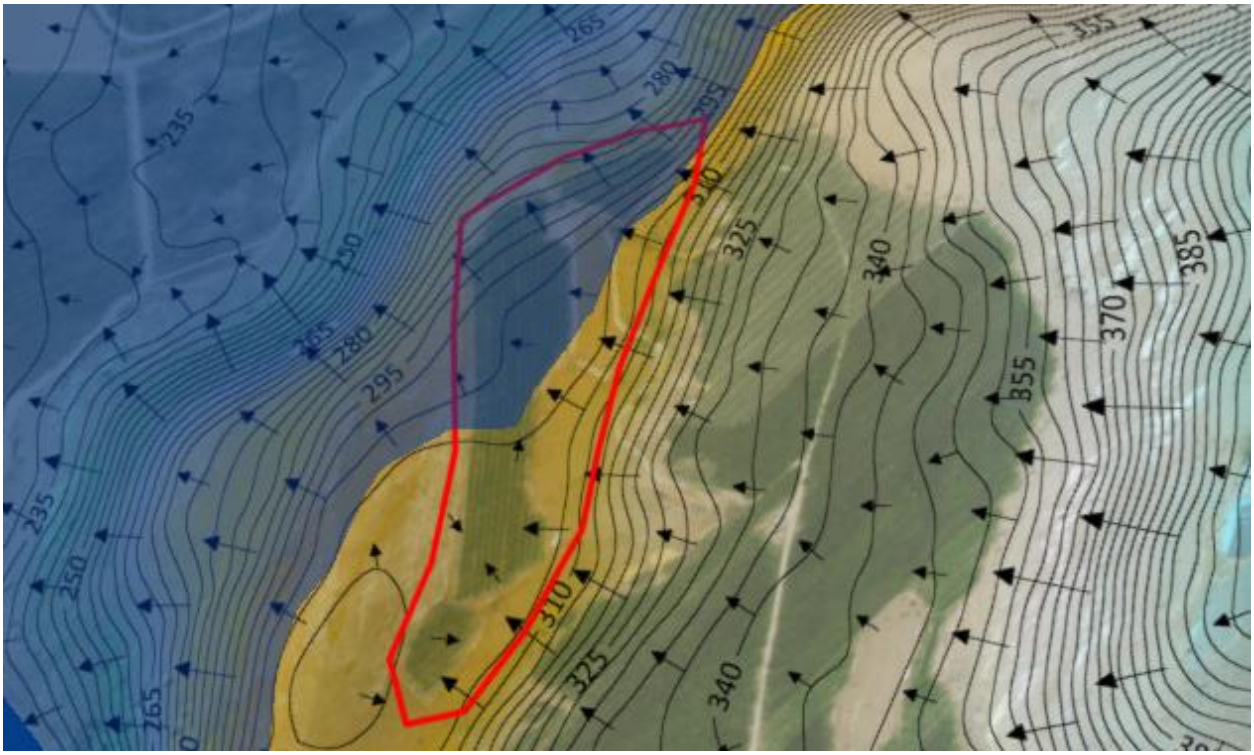


Soil


WA017 [1:12,000] (1998) Export: 2021-08-23
380: Supplee ashy very fine sandy loam, 3 to 8 percent slopes (700532)
Supplee (85%)
Dry Loamy 10-16 PZ
Vitritorrandic Haploxerolls
Well drained
Hydric: No
0
A
23
Bw1
46
Bw2
69
2C
152
terraces
380

Cold Air Flooding Pattern





Notes

Cold Air Drain® units are to be located in the lowest or most convenient spots nearest the recommended locations.

Keep a clear area of approximately 20 feet around the machine.

Maintain cover crop at 3 inches or less in height for better air flow.

Cold Air Drain® come ready to run with a tractor PTO. PTO shaft is included.

Optional power units include gas, propane and electric.

Gas and Propane power units can be equipped with a standalone or telematics auto start and solar battery chargers.

Electric power units come standard with standalone Autostart.

We make every effort to get units shipped promptly. However, lead times can be up to 6-8 weeks.

The Physics of Frost

Growers know too well the effects of frost, but few may understand the physics behind how it develops. Such an understanding is useful when figuring out how to protect your crop from frost damage.

First, it is important to understand that there are two types of frost, radiation and advective.

Advective frost occurs during your typical winter storm. Dynamic cold air masses, cloud cover, and absence of an inversion layer characterize advective frost. Cold air during advective nights is generated from dynamic cold air masses flowing in, typically from coastal regions. During advective nights, most frost protection methods are ineffective in providing protection. However, most growers avoid advective frost damage by planting crops suitable for their regional climate, planting varieties that bud later, or change pruning schedules to also delay growth and budding. In general, plants are dormant during advective frost nights. There are methods that may have some effect combating advective frost, but economic feasibility is a major deterrent for regular use.

Radiation frost occurs during nights with clear skies, no wind and the presence of an inversion layer. During the day, the earth is heated by short wave radiation from the sun. Clear skies allow for maximum absorption of the suns radiation. In addition, dense, moist soil has the highest capacity to absorb the sun's radiation. Short wave radiation stops after the sun goes down and the earth begins to lose its heat through long wave radiation. Whereas moist, dense soil holds the most heat, it also releases heat the slowest at night. This is why running your under-vine sprinklers during frost is a great overlaying protection method with Cold Air Drains.

The long wave radiation from the earth is what actually generates the cold air during radiation nights. As the ground begins to chill from heat loss, it chills the air closest to ground level. This deferential cooling is what creates the inversion layer. Cool, dense air at ground level and warmer, lighter air above. Without obstructions like clouds, the earth will continue to cool and add more cold air at ground level until short wave radiation commences with sunrise. This is why it is coldest right before dawn.

So why does frost damage occur during radiation nights? The answer is katabatic flow. The coldest, most dense air molecules closest to the ground flow downhill like water. This movement is known as katabatic flow. This is also why the low spots in your field are always the coldest. As more cold air flows into those accumulation areas, it continues to condense and get colder. After enough accumulation occurs and gets deep enough to reach plant tissue at critical temperatures, you will get frost damage.

Clouds and a higher relative humidity will slow long wave radiation. In addition, wind helps move cold air out of the accumulation areas and mix up the inversion layer. If the sun's radiation was obstructed during the day and there was a breeze, then the air temperature will be cooler before sunset. Starting with lower temperature at sunset only aids to the risk. Greatest risk for frost damage is imminent with a combination of low temperature before sunset, clear skies, no wind and a low relative humidity. Dry, lose soils will also augment the risk factor.

Cold air can accumulate seven ways. The two most common are Cold Air Lakes and Cold Air Flooding. Cold Air Lakes occur when cold air flows into low spots with no drainage, like a lake. Cold Air Flooding occurs where there is more cold air flowing into an area than can drain out. With insufficient or no drainage, cold air accumulation can build up high enough to submerges plant tissue and cause frost damage. Keeping cover crops mowed down and vegetation at the bottom of growing areas sparse is vital for aiding drainage.

As long as there is sufficient drainage to prevent accumulation, you are at much lower risk of frost damage. We know this because frost damage generally does not occur on hillsides.

Understanding the physics behind frost and cold air accumulation should be the first step to protecting your crops from frost damage. The best protection comes from mitigating cold air coming in with passive measures, encouraging cold air flowing out with proper cultural practices and site placement and draining any accumulation areas left with active measures.