

January 15, 2009

### Integrated On-Farm Drainage Management (salt management & disposal)

#### Where does the salt come from?

Naturally occurring salts and trace elements are constituents of the marine soils of western Fresno and Kings Counties. Additionally, local ground water and imported surface water contain dissolved salts and trace elements. To make matters worse, many of the pesticides, fertilizers, soil amendments, and manures we use add salts to our soil and water. Across the San Joaquin Valley, 275 tons of salt per hour are added to our soil by the use of farm chemicals and irrigation water.

Two ways to express salinity

Electrical conductivity (EC) of soil or water expressed in deciSiemens per meter or dS/m, a measure of electrical conductivity, and indicates the proportion of salts in a sample of soil or water. Higher EC and dS/m figures indicate higher irrigation water salinity. See Table 2. Salt sensitive vegetables like carrots require a water salinity of less than 2 dS/m, but salt tolerant trees like pistachios grow well with water salinity in the 5-10 dS/m range.

Another way salinity is expressed is totally dissolved solids (TDS) shown in parts per million or ppm. To describe water salinity, milligrams per liter or mg/L is often used. There are 1,000 milligrams in a gram. The salinity of water that has 100 milligrams of salt per liter is expressed as 100 mg/L.

Table 2. Comparison of salinity tolerance and profit potential for various plants in an IFDM system.

Plants	Irrigation water salinity (EC) (fresh, mixed, or drainage)	Profit Potential
Salt-sensitive vegetables	below 2 dS/m <sup>†</sup>	high
Salt-tolerant vegetables & flowers	below 6 dS/m	medium
Field crops (cotton, wheat, canola )	below 8 dS/m	low
Salt-tolerant forages	8-15 dS/m <sup>††</sup>	low
Halophytes	Above 15 dS/m	none - low
Salt-tolerant trees	5-10 dS/m	none - low

<sup>†</sup>Most require irrigation water less than 2 dS/m. Optimal soil and water management is required to use waters from 2 to 4 dS/m.

<sup>††</sup>Over the short term, Jose Tall Wheatgrass, Paspalum, creeping wild rye and bermuda grass can be irrigated with water up to 20 dS/m.

### **How does saline water migrate and accumulate on the west side?**

In the Westlands Water District farmers typically apply 15%-20% more water than their crops need to wash salts and trace elements down past the root zones of their crops. This practice provides clean soil and water for crops but causes saline water to accumulate atop an impermeable clay layer that lies 5 to 20 feet below the surface. This clay layer slopes downhill from the Coastal Range foothills to the valley trough. Cropland in the eastern part of the Westlands Water District near the valley trough is impacted by an accumulation of saline water that flows underground from uphill farms. The clay soils in the eastern part of the Westlands Water District trap this drain water, heavily laden with salts like sodium sulfate and trace elements like selenium, and locally applied irrigation water, which saturates the soil profile. Few if any crops grow in these soils because of the salt and trace element contamination. Without a drainage canal to carry these contaminants away, farmers in the Westlands Water District have to devise a way to clean up the soil and water on their farms. The Westside Resource Conservation District has supported the development of an on-farm drainage management system called Integrated On-Farm Drainage Management (IFDM) to restore the soil and water quality.

### **INTEGRATED ON-FARM DRAINAGE MANAGEMENT (IFDM)**

IFDM has three goals: 1) detoxify a maximum acreage of cropland to grow high value crops (usually salt-sensitive crops); 2) use salt tolerant crops and grasses and halophytes (plants that thrive on saline water) to extract water, remove trace elements, and concentrate salts for disposal in a solar evaporator; and 3) eliminate the need for off-farm disposal of salts and other soil contaminants. It should be noted that irrigation water must be applied precisely and drainage interception must be calibrated carefully to sustain an IFDM system. If too much water is applied or too much drain water is collected, or both, the resulting amount of drain water can be too large for the system to process.

There are farms that have drainage lines under fields that are impacted by migrating drain water. Draining saline water from these fields keeps them productive. The drainage water from these fields is blended with fresh water to irrigate a salt tolerant crop in a field 1/16 the size of the drained area. Drain water from this small field is then used to irrigate a salt tolerant grass in a field 1/9 the size of the small field. Salts and other contaminants accumulate in this tiny field, with no assurance they will stay there. These drainage systems are not complete IFDM systems, because they do not safely dispose of harmful contaminants. IFDM systems, on the other hand, use solar evaporators to dispose of contaminants. Some integrated on-farm drainage management systems use three stages, and some use four. Let's examine the objective(s) of each stage of a four stage IFDM system. See Figure 3.

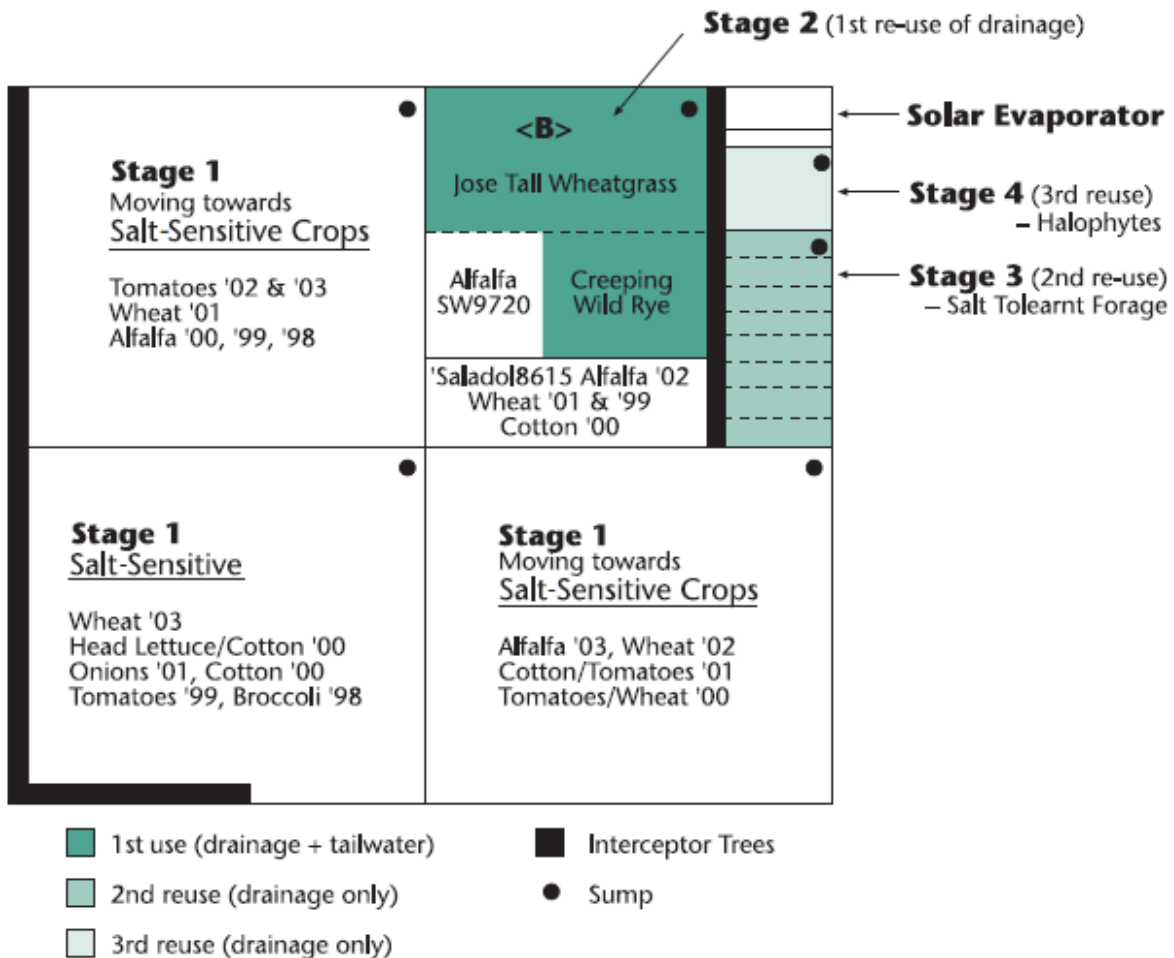


Figure 3. Red Rock Ranch IFDM. Sequential reuse, 4 stages (640 acres).

The objective of stage 1, in which low salinity fresh water is used both to irrigate and to wash contaminants to underground drainage pipes, is to maximize revenues from high value, salt-sensitive crops on restored cropland. The objectives of stage 2, where drain water from stage one is blended with fresh water to irrigate salt-tolerant crops and grasses, are to remove trace elements, extract water, concentrate salts, and earn as much income as possible from field crops and forage. The objectives of stage 3, where drain water from stage 2 is blended with fresh water to irrigate salt-tolerant grasses, are to extract water and trace elements, concentrate salts, and gain revenues from forage sales. The objective of stage 4, where drain water from stage 3 irrigates halophytes (salt-loving plants), is to extract water from the drain water and thereby concentrate salts in the drain water from stage 4.

**Table 4.** Example of Maas Hoffman salinity tolerance coefficients and slopes for field crops and vegetables (Maas & Grattan, 1999).

	<b>Maas Hoffman Salinity Tolerance Values</b>		
	Threshold soil salinity (ECe) in dS/m	Maximum water salinity (ECiw in dS/m) that can be used without yield reduction*	Slope (% yield reduction per unit dS/m increase)
<b>Salt-Tolerant Field Crops</b>			
Cotton	7.7	5.1	5.2
Wheat	6.0	4.0	7.1
Barley	8.0	5.3	5.0
Sugarbeet	7.0	4.7	5.9
Canola ( <i>B. napus</i> )	11.0	7.3	13
Canola ( <i>B. campestris</i> )	9.7	6.5	14
<b>Salt-Tolerant Vegetables</b>			
Artichoke	6.1	4.1	11.5
Asparagus	4.1	2.7	2.0
Red beet	4.0	2.7	9.0
Zucchini squash	4.9	3.3	10.5
Purslane	6.3	4.2	9.6
<b>Moderately Salt-Sensitive Vegetables</b>			
Garlic	3.9	2.6	14.3
Pea	3.4	2.3	10.6
Broccoli	2.8	1.9	9.2
Tomato	2.5	1.7	9.9
<b>Salt-Sensitive Vegetables</b>			
Carrot	1.0	0.7	14.0
Onion	1.2	0.8	16.0
Bean	1.0	0.7	19.0

\* assumes 15-20% leaching fraction

Lastly, the drain water from stage 4 is a concentrated brine that is pumped to the solar evaporator, where the salts and other remaining contaminants are disposed of. The solar evaporator is a large flat area underlain by a liner or an impenetrable clay layer and bordered by levees. Salt brine is delivered there by timed sprinklers to avoid the puddling of water. This practice precludes the attraction of birds and other animals to the solar evaporator. If they drank the contaminated water, they could be poisoned.

The IFDM operator can: 1) collect salt from the solar evaporator, clean it, and sell it; 2) seal the entire solar evaporator to prevent salts and other contaminants from leaking out; or 3) remove the salts and other contaminants from the solar evaporator and haul them to a hazardous waste facility. The first two options keep contaminants from going off the

farm. The third option contradicts the IFDM goal of eliminating the need of off-farm disposal of salts and other soil contaminants.

Trees are not necessarily used in IFDM systems, but they can aid the extraction of saline water and the reduction of salts in shallow ground water. They can be planted in tree lines that cut across regional subsurface flows of drainage water to intercept saline water. Or they can be planted in crop fields on the same intervals that perforated pipe would be placed underground to drain the fields. On such spacing, trees can actually “pump” saline water out of the root zone of crops and function as biological drains. Alternatively solid plantations of pistachio trees underlain with subsurface drain lines consume most of the saline ground water and let a greatly reduced quantity of saline water flow to the drain pipes. Athel, eucalyptus, Argentine mesquite, and pistachio trees are good trees for these applications.