UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
NEW MEXICO

SOIL INTERPRETATIONS FOR IRRIGATION - NARRATIVE

GENERAL

This narrative explains the development of the attached "Soil Interpretations for Irrigation" and defines some of the terms used in this material. For the field office or geographic area for which it was prepared, "Soil Interpretations for Irrigation" contains the irrigation characteristics, recommendations for maximum irrigation grades, and the adapted conservation irrigation systems.

The irrigation characteristics of the soils, as shown in the attached tables, are the best data presently available. Every effort should be made to verify the data shown in columns 3 through 10, by using farm irrigation evaluations and irrigation trials. As the data is verified, the irrigation systems developed from this data will be greatly improved. Irrigation water management will also improve as landowners and technicians use this data of greater reliability.

The criteria contained in "Soil Interpretations for Irrigation" is to be used in obtaining irrigation water management and in the planning of farm irrigation systems for the field office. If, through evaluations and irrigation trials, the data in these interpretations is found to be inadequate, a recommendation should be submitted for revising the material to include the new data. These recommendations should be submitted in accordance with instructions for revising the Field Office Technical Guide.

Soils in the attached material are grouped according to similar irrigation characteristics and are listed by increasing intake families. All soils in a group have similar irrigation characteristics which include:

1. Available moisture holding capacity in inches per foot of soil depth.

2. Moisture replacement depth from which plants remove moisture that must be replaced by irrigation water.

3. Net moisture to be replaced for each of the crop groups.

4. Family intake curve designation assigned to the soil for irrigation purposes.

DEFINITIONS

Crop Groups - A group of crops having similar irrigated rooting depths and soil moisture extraction patterns when there are no soil limitations. Generally, these crops are grouped as shown below:

Shallow Rooted	Medium Rooted	Deep Rooted
Onions	Cotton	Alfalfa
Lettuce	Sorghums	Pecans
Carrots	Soybeans	Orchards
Cabbage	Small grain	Grapes
Potatoes	Corn	
Peanuts	Sugar beets	
Pinto beans	Tomatoes	
Chili	Melons	
Most vegetables	Pasture grasses	
	Sunflowers	

Additional crops can be added to those shown above as needed by the Field Office.

MOISTURE REPLACEMENT DEPTH (feet)

The depth of soil to be refilled at each irrigation during the maximum consumptive use period of the crop growing season. This varies with crops and soils. The moisture replacement depths shown are for the period of peak or maximum consumptive use and are shown in columns 4, 6, and 8 of "Soil Interpretations for Irrigation".

NET MOISTURE TO BE REPLACED (inches)

The moisture required to fill the soil to field capacity to the moisture replacement depth when approximately one-half of the available moisture has been depleted. These values are shown in columns 5, 7, and 9 of "Soil Interpretations for Irrigation". The net moisture to be replaced is calculated by taking 50% (to the nearest, lowest, half-inch) of the total available moisture holding capacity per foot of soil depth (column 3) within the moisture replacement depth (columns 4, 6, or 8).

AVAILABLE MOISTURE HOLDING CAPICITY PER FOOT OF SOIL DEPTH (inches)

The inches of water which a plant can remove from a one-foot depth of soil profile. For each group of soils, beginning with the soil surface, and in the same order as found in the soil profile, figures are given for the amount of available moisture from the surface to the end of the irrigated root zone.

FAMILY INTAKE CURVE DESIGNATION (curve number)

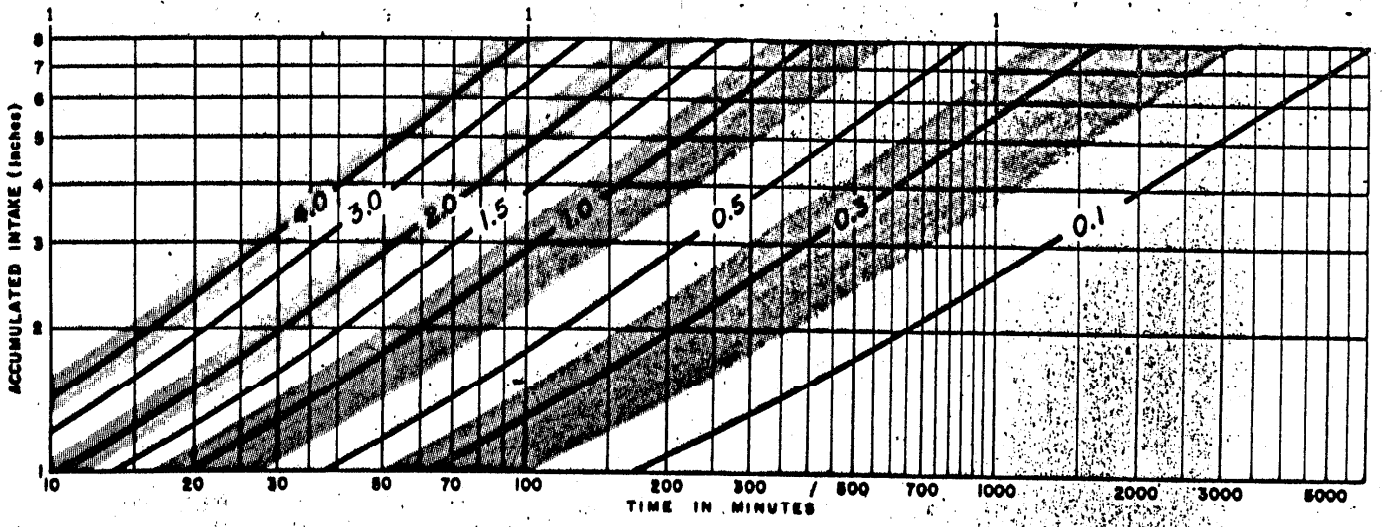
The figure entered in column 10 shows the approximate curve number for determining the design intake rate for irrigation systems. These curve numbers are shown in the attached graph and table.

MAXIMUM IRRIGATION GRADE

The figure in column 11 indicates the maximum recommended irrigation grade in feet per hundred feet for the soil group.

ADAPTED CONSERVATION IRRIGATION SYSTEMS

The "X" shown in columns 12 through 17 indicates the type of farm irrigation systems adapted to the soil group concerned.



INTAKE GROUPING for SURFACE IRRIGATION DESIGN

Intake Family	Net Depth of Application in Inches							
	1.0	1.5	2.0	2.5	3.0	4.0	5.0	6.0
	Time in Minutes							
0.1	169	374	628	923	1255	2014	2886	3858
0.3	62	129	208	296	392	604	841	1100
0.5	38	75	119	166	217	328	450	580
1.0	20	38	59	82	106	158	214	273
1.5	14	26	40	56	72	106	143	181
2.0	11	20	31	42	54	80	107	136
3.0	7	14	21	29	37	54	72	91
4.0	6	11	16	22	28	41	55	69

Table
Field Crops —

Crop	EC_e[2]	EC_w[3]	LR	EC_e	EC_w	LR
		(0%)			*(10%)*	
Barley[5]	8.0	5.3	9%	10.0	6.7	12%
Cotton	7.7	5.1	9%	9.6	6.4	12%
Sugar beets[6]	7.0	4.7	10%	8.7	5.8	12%
Wheat[5, 7]	6.0	4.0	10%	7.4	4.9	12%
Safflower	5.3	3.5	12%	6.2	4.1	14%
Soybeans	5.0	3.3	16%	5.5	3.7	18%
Sorghum	4.0	2.7	8%	5.1	3.4	9%
Rice (paddy)	3.0	2.0	9%	3.8	2.6	11%
Corn	1.7	1.1	6%	2.5	1.7	8%
Flax	1.7	1.1	6%	2.5	1.7	8%
Cowpeas	1.3	0.9	5%	2.0	1.3	8%
Beans (field)	1.0	0.7	5%	1.5	1.0	8%
Broadbean	1.6					
Peanut	3.2			3.5		
Sugarcane	1.7					

[1]Adapted from Quality of Water for Irrigation. R. S. Ayers. *Jour. of the Irrig. and Drain. Div.*, ASCE. Vol. 103, No. IR2, June 1977, p. 140, and Salt Tolerance of Plants. E. V. Maas. *Appl. Agri. Res.*, Vol. 1, No. 1, 1986, p. 12-26.

[2]EC_e means electrical conductivity of the saturation extract of the soil reported in dS/m at 25°C.

[3]EC_w means electrical conductivity of the irrigation water in dS/m at 25°C.

[4]Maximum EC_e is the electical conductivity of the soil saturation extract at which crop growth ceases.

the water passes through the soil and reaches equilibrium with it. If the SAR is less than 6, there should be no problems with either sodium or permeability. In the range of 6 to 9, there are increasing problems; above 9, severe problems can be expected.

Reducing sodium related permeability problems may be accomplished by:

1. Applying a source of soluble calcium (gypsum) to the soil or directly in the irrigation water.

2-7
Reduction in Yield[1]

EC_e	EC_w	LR	EC_e	EC_w	LR	EC_e[4]
	(25%)			*(50%)*		*(Maximum)*
13.0	8.7	16%	18.0	12.0	21%	28.0
13.0	8.4	16%	17.0	12.0	22%	27.0
11.0	7.5	16%	15.0	10.0	21%	24.0
9.5	6.4	16%	13.0	8.7	22%	20.0
7.6	5.0	17%	9.9	6.6	23%	14.5
6.2	4.2	21%	7.5	5.0	25%	10.0
7.2	4.8	13%	11.0	7.2	20%	18.0
5.1	3.4	15%	7.2	4.8	21%	11.5
3.8	2.5	12%	5.9	3.9	20%	10.0
3.8	2.5	12%	5.9	3.9	20%	10.0
3.1	2.1	12%	4.9	3.2	19%	8.5
2.3	1.5	12%	3.6	2.4	18%	6.5
						6.6

[5]Barley and wheat are less tolerant during germination and seedling stage. EC_e should not exceed 4 or 5 dS/m.

[6]Sensitive during germination. EC_e should not exceed 3 dS/m for garden beets and sugar beets.

[7]Tolerance data may not apply to semi-dwarf varieties of wheat.

2. Reducing the pH and bicarbonate content of the irrigation water by adding sulfuric acid.
3. By incorporating sulfur in problem soils, provided adequate free lime is present. See Table 2-11.

The adjusted SAR (SAR_a) presented in previous editions of this handbook, and still reported by many laboratories, is no

Table
Vegetable Crops —

Crop	EC_e	EC_w	LR	EC_e	EC_w	LR
		(0%)			*(10%)*	
Beets[2]	4.0	2.7	9%	5.1	3.4	11%
Broccoli	2.8	1.9	7%	3.9	2.6	10%
Tomatoes	2.5	1.7	7%	3.5	2.3	9%
Cantaloupes	2.2	1.5	5%	3.6	2.4	8%
Cucumbers	2.5	1.7	8%	3.3	2.2	11%
Spinach	2.0	1.3	4%	3.3	2.2	7%
Cabbage	1.8	1.2	5%	2.8	1.9	8%
Potatoes	1.7	1.1	6%	2.5	1.7	9%
Sweet corn	1.7	1.1	6%	2.5	1.7	9%
Sweet potatoes	1.5	1.0	5%	2.4	1.6	8%
Peppers	1.5	1.0	6%	2.2	1.5	9%
Lettuce	1.3	0.9	5%	2.1	1.4	8%
Radishes	1.2	0.8	4%	2.0	1.3	7%
Onions	1.2	0.8	5%	1.8	1.2	8%
Carrots	1.0	0.7	4%	1.7	1.1	7%
Beans	1.0	0.7	5%	1.5	1.0	8%
Celery	1.8					
Squash (scallop)	3.2					
Squash (zucchini)	4.7					
Turnip	0.9					

[1]Adapted from Quality of Water for Irrigation. R. S. Ayers. *Jour. of the Irrig. and Drain. Div.*, ASCE. Vol. 103, No. IR2, June 1977, p. 140, and Salt Tolerance of Plants. E. V. Maas. *Appl. Agri. Res.*, Vol. 1, No. 1, 1986, p. 12-26.

[2]Sensitive during germination. EC_e should not exceed 3 dS/m for garden beets and sugar beets.

longer recommended. Careful evaluation by researchers reveal that this procedure overstates the effects of bicarbonate and carbonate (HCO_3^- and $CO_3^=$) on the resulting sodium hazard. If the SAR_a is to be used, the value should be further adjusted by a 0.5 multiplication factor to more accurately define the

2-8
Reduction in Yield[1]

EC_e	EC_w	LR	EC_e	EC_w	LR	EC_e
	(25%)			*(50%)*		*(Maximum)*
6.8	4.5	15%	9.6	6.4	21%	15.0
5.5	3.7	14%	8.2	5.5	20%	13.5
5.0	3.4	14%	7.6	5.0	20%	12.5
5.7	3.8	12%	9.1	6.1	19%	16.0
4.4	2.9	14%	6.3	4.2	21%	10.0
5.3	3.5	12%	8.6	5.7	19%	15.0
4.4	2.9	12%	7.0	4.6	19%	12.0
3.8	2.5	13%	5.9	3.9	20%	10.0
3.8	2.5	13%	5.9	3.9	20%	10.0
3.8	2.5	12%	6.0	4.0	19%	10.5
3.3	2.2	13%	5.1	3.4	20%	8.5
3.2	2.1	12%	5.2	3.4	19%	9.0
3.1	2.1	12%	5.0	3.4	19%	9.0
2.8	1.8	12%	4.3	2.9	19%	7.5
2.8	1.9	12%	4.6	3.1	19%	8.0
2.3	1.5	12%	3.6	2.4	18%	6.5

effects of bicarbonate on calcium precipitation. Newer and more accurate calculations for estimating the effects of bicarbonate have been developed. As a result, SAR is more correctly being reported as SAR_{adj}. The standards are synonymous for interpretive purposes.

Table
Fruit and Nut Crops –

Crop	EC_e	EC_w	LR	EC_e	EC_w	LR
		(0%)			*(10%)*	
Date palms	4.0	2.7	4%	6.8	4.5	7%
Figs, Olives, Pomegranates	2.7	1.8	6%	3.8	2.6	9%
Grapefruit	1.8	1.2	8%	2.4	1.6	10%
Oranges	1.7	1.1	7%	2.3	1.6	10%
Lemons	1.7	1.1	7%	2.3	1.6	10%
Apples, Pears	1.7	1.0	6%	2.3	1.6	10%
Walnuts	1.7	1.1	7%	2.3	1.6	10%
Peaches	1.7	1.1	8%	2.2	1.4	11%
Apricots	1.6	1.1	9%	2.0	1.3	11%
Grapes	1.5	1.0	4%	2.5	1.7	7%
Almonds	1.5	1.0	7%	2.0	1.4	10%
Plums	1.5	1.0	7%	2.1	1.4	10%
Blackberries	1.5	1.0	8%	2.0	1.3	11%
Boysenberries	1.5	1.0	8%	2.0	1.3	11%
Avocados	1.3	0.9	8%	1.8	1.2	10%
Raspberries	1.0	0.7	6%	1.4	1.0	9%
Strawberries	1.0	0.7	9%	1.3	0.9	11%

[1]Adapted from Quality of Water for Irrigation. R. S. Ayers. *Jour. of the Irrig. and Drain.* Div., ASCE. Vol 103, No. IR2, June 1977, p. 142.

Irrigation water with a very low salt content may also present a water infiltration problem. In this case the addition of some salt, preferably a calcium source, would be helpful. There is evidence that all irrigation waters should have a minimum calcium content of 20 ppm (1.0 me/l), and EC_w of at least 0.5 dS/m to prevent dispersion of the soil.

2-9
Reduction in Yield[1]

EC_e	EC_w	LR	EC_e	EC_w	LR	EC_e
	(25%)			*(50%)*		*(Maximum)*
10.9	7.3	11%	17.9	12.0	19%	32.0
5.5	3.7	13%	8.4	5.6	20%	14.0
3.4	2.2	14%	4.9	3.3	21%	8.0
3.2	2.2	14%	4.8	3.2	20%	8.0
3.3	2.2	14%	4.8	3.2	20%	8.0
3.3	2.2	14%	4.8	3.2	20%	8.0
3.3	2.2	14%	4.8	3.2	20%	8.0
2.9	1.9	15%	4.1	2.7	21%	6.5
2.6	1.8	15%	3.7	2.5	21%	6.0
4.1	2.7	11%	6.7	4.5	19%	12.0
2.8	1.9	14%	4.1	2.7	19%	7.0
2.9	1.9	14%	4.3	2.8	20%	7.0
2.6	1.8	15%	3.8	2.5	21%	6.0
2.6	1.8	15%	3.8	2.5	21%	6.0
2.5	1.7	14%	3.7	2.4	20%	6.0
2.1	1.4	13%	3.2	2.1	19%	5.5
1.8	1.2	15%	2.5	1.7	21%	4.0

It is now more fully understood that water infiltration is a factor of both water salinity (EC_w) and sodium (SAR) concentrations. Water infiltration rates generally tend to increase with increases in water salinity, and decrease with either decreasing salinity or increasing sodium, as SAR. Figure 2-5 is useful for estimating the combined effects of water salinity and sodium concentrations (SAR) on the resulting infiltration rate of soils.

Table
Forage Crops —

Crop	EC_e	EC_w	LR	EC_e	EC_w	LR
		(0%)			*(10%)*	
Tall wheat grass	7.5	5.0	8%	9.9	6.6	10%
Wheat grass (fairway)	7.5	5.0	11%	9.0	6.0	14%
Bermudagrass	6.9	4.6	10%	8.5	5.7	13%
Barley (hay)[2]	6.0	4.0	10%	7.4	4.9	12%
Perennial ryegrass	5.6	3.7	10%	6.9	4.6	12%
Birdsfoot trefoil, narrow leaf	5.0	3.3	11%	6.0	4.0	13%
Harding grass	4.6	3.1	9%	5.9	3.9	11%
Tall fescue	3.9	2.6	6%	5.8	3.9	8%
Crested wheat grass	3.5	2.3	4%	6.0	4.0	7%
Vetch	3.0	2.0	8%	3.9	2.6	11%
Sudan grass	2.8	1.9	4%	5.1	3.4	7%
Big trefoil	2.3	1.5	10%	2.8	1.9	13%
Alfalfa	2.0	1.3	4%	3.4	2.2	7%
Clover, berseem	1.5	1.0	3%	3.2	2.1	6%
Orchardgrass	1.5	1.0	3%	3.1	2.1	6%
Meadow foxtail	1.5	1.0	4%	2.5	1.7	7%
Clover, alsike, ladino, red, strawberry	1.5	1.0	5%	2.3	1.6	8%
Lovegrass	2.0					
Wheatgrass	3.5					
Wildrye	2.7					

[1]Adapted from Quality of Water for Irrigation. R. S. Ayers. *Jour. of the Irrig. and Drain. Div.*, ASCE. Vol. 103, No. IR2, June 1977, p. 140, and Salt Tolerance of Plants. E. V. Maas. *Appl. Agri. Res.*, Vol. 1, No. 1, 1986, p. 12–26.

[2]Barley and wheat are less tolerant during germination and seedling stage. EC_e should not exceed 4 or 5 dS/m.

2–10
Reduction in Yield[1]

EC_e	EC_w	LR	EC_e	EC_w	LR	EC_e
	(25%)			*(50%)*		*(Maximum)*
13.3	9.0	14%	19.4	13.0	21%	31.5
11.0	7.4	17%	15.0	9.8	22%	22.0
10.8	7.2	16%	14.7	9.8	22%	22.5
9.5	6.3	16%	13.0	8.7	22%	20.0
8.9	5.9	16%	12.2	8.1	21%	19.0
7.5	5.0	17%	10.0	6.7	22%	15.0
7.9	5.3	15%	11.1	7.4	21%	18.0
8.6	5.7	12%	13.3	8.9	19%	23.0
9.8	6.5	11%	16.0	11.0	19%	28.5
5.3	3.5	15%	7.6	5.0	21%	12.0
8.6	5.7	11%	14.4	9.6	18%	26.0
3.6	2.4	16%	4.9	3.3	22%	7.5
5.4	3.6	12%	8.8	5.9	19%	15.5
5.9	3.9	10%	10.3	6.8	18%	19.0
5.5	3.7	11%	9.6	6.4	18%	17.5
4.1	2.7	11%	6.7	4.5	19%	12.0
3.6	2.4	12%	5.7	3.8	19%	10.0