NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

SALINITY AND SODIC SOIL MANAGEMENT

(Ac.)

Code 610

DEFINITION

Management of land, water and plants to control and minimize accumulations of salts and/or sodium on the soil surface and in the crop rooting zone.

PURPOSE

- To reduce and control harmful salt concentrations in the root zone
- To reduce problems of crusting, permeability, or soil structure on sodium affected soils
- To promote desired plant growth and to utilize excess water in the root zone in non-irrigated saline seep areas and their recharge areas

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all land uses where the concentration or toxicity of salt limits the growth of desirable plants or where excess sodium causes crusting and permeability problems. This practice also applies to non-irrigated land where a combination of factors such as topography, soils, geology, precipitation, vegetation, land use and cultural/structural practices can increase the extent and concentration of salts in saline seep areas.

CRITERIA

GENERAL CRITERIA APPLICABLE TO ALL PURPOSES

All work, including associated practices for management of drainage and runoff, shall comply with Federal, State, and local laws and regulations.

Additional Criteria to Reduce Salt Concentrations in the Root Zone and to Reduce Problems of Crusting, Permeability, or Soil Structure on Sodium-affected Soils

Identifying Toxic Salt Areas

Saline Soils

Naturally developed saline soils usually represent only small areas of a field but can extend to larger areas. Often, these areas are found in bottomlands which have poor internal drainage and a shallow water table. Other small areas occur on slopes where erosion has exposed saline subsoil. Soil surveys often indicate the location and extent of saline soils.

Capillary rise from the shallow water table carries soluble salts occurring in the soil or bedrock to the surface. The water evaporates on the soil surface and leaves behind salts.

These soils are also frequently wet during cultivation and can become compacted in and around the wet areas. Surface water will not move easily through the compacted soil, so more water evaporates on the surface leaving the salts to accumulate and the effected area to get larger with time. A very thin white crust will develop on the soil surface as the soil dries.

Crop production is reduced in these areas due to the salt accumulation. Seedling plants are very sensitive to water stress which leads to stand reduction.

Saline soils generally have a very good soil physical condition throughout the tillage depth. When these soils are not too wet, they are friable, mellow, and easily tilled.

Soil which has been saline for several years will have the following characteristics:

- Fertile and high in N, P, and K. Nutrients build up in salty areas because of limited crop growth and removal over time.
- Soil pH is less than 9.
- Electrical Conductivity (EC) of the soil extract is greater than 4 mmho/cm at 25°C. The EC is generally consistent throughout the soil profile.
- Sodium Adsorption Ratio (SAR) is less than 13.
- Exchangeable Sodium Percentage (ESP) is less than 15%.

Alkali (Sodic) Soils

Alkali soils contain excessive amounts of sodium. This can result from excess sodium in the subsoil by mineral weathering or sodium rich water applied to the surface.

Sodium forces the soil particles to separate and causes the soil to disperse. Alkali soils are not friable and mellow like saline soils. Instead alkali soils are greasy when wet, especially if it is fine textured and often very hard when dry. They are often characteristically too wet or too dry for tillage. Therefore, poor seed germination and stand establishment are common because good seedbed preparation is difficult.

The pores in the soil which allow water to infiltrate become plugged with the dispersed clay and organic material. As a result, the subsoil is very dry even though water is ponding on the surface. Plants in the area often suffer water stress and may eventually die from lack of water and oxygen.

The dispersed clay or organic material floating in the water are left on the soil surface after the water evaporates. The surface color will be darker than the rest of the field when organic material is left and lighter in color when clay and salts are left when the surface dries.

Alkali soils will have the following characteristics:

- Exchangeable Sodium Percentage (ESP) greater than 15%.
- Sodium Adsorption Ratio (SAR) greater than 13.
- pH greater than 9
- Electrical Conductivity (EC) of the soil extract is less than 4 mmho/cm at 25°C.

Saline – Sodic Soils

Saline – Sodic soils will have the following characterisitics:

- Exchangeable Sodium Percentage (ESP) greater than 15%.
- Sodium Adsorption Ratio (SAR) greater than 13.
- pH greater than 9.

Induced Saline or Alkali Soils

Saline and/or sodic soils can be induced with liquid wastes from saltwater brine released from oil wells.

Saltwater brine is concentrated sodium chloride along with other salts and possibly toxic elements. It can result from seepage of evaporation ponds, leakage from wells and pipelines or from unloading tank trucks at the site.

These sites have soils that are dispersed, have a white crust and are mostly bare of vegetation. Soil erosion is generally active at the site which has exposed the subsoil.

Determination of Saline and Alkaline Soils

Saline and alkaline soils have similar characteristics and can be confused with each other. Verifying the soil condition present is best done with soil testing.

Problem areas shall be evaluated in one of the following ways:

1. A soil scientist will evaluate the site with a salinity meter

   or

2. Soil samples will be taken and tested for salinity at the Oklahoma State University soils lab or any other soils lab using the same testing procedures and approved through the North American Proficiency Testing Program.

Soil samples will be collected in accordance with OSU Fact Sheet 2207 – How to Get a Good Soil Sample. Suspected areas should be sampled separately from the rest of the field. A salinity management analysis will be done on the soil sample. This analysis includes results for Na, Ca, Mg, K, B, EC, TSS (total soluble salts), Sodium Adsorption Ratio (SAR), Exchangeable Sodium Percentage (ESP), and pH. It is best to sample during a dry period of the growing season and should be taken at least one week after the last rain. Samples should only be taken from the top 1 to 3 inches of soil (seeding depth).

Whenever the source of the salt or sodium is external, such as brine from oil wells, eliminate the source as soon as possible.

On irrigated lands, leaching requirements shall be determined as presented in the NRCS National Engineering Handbook Part 623, Chapter 2.

Apply conservation practices as needed to control erosion on the site.

Management of Saline and Alkaline Soils

Improve Internal Soil Drainage

Salt concentrations in the soil profile must be reduced in the plant root zone. Internal drainage in the soil profile must be good enough so that water can easily pass through the soil to leach salts out of the root zone.

There are a number of ways internal drainage can be improved. Tile drains and open ditches are effective in lowering subsoil water that accumulates above compacted clay and bedrock zones. The water table needs to be lowered to a minimum of 6 ft. below the soil surface for clays and loams and 4 ft. for sandy loams or lighter textured soils.

Compacted soil layers near the soil surface need to be broken up by using deep tillage implements. The soil has to be dry enough to have a shattering effect on the hardpan layer. Refer to guidance in the Oklahoma NRCS Deep Tillage (324) standard and specification.

Incorporate Organic Material

Once internal drainage is assured, the water movement into the soil must be improved. Incorporating 15 to 20 tons/ac of organic material into the top 4 to 6 inches creates large pore space for water to enter the soil. Organic material will be applied according to the Oklahoma NRCS Mulching (484) standard and specification under the criteria for improving soil condition and fertility - saline and alkali soil.

Apply Gypsum to Alkali Soils

Management for saline and alkali soils is the same to this point. Alkali soils will require additional treatment.

Sodium is attached to soil particles very tightly and must be replaced before it can be leached through the soil. Gypsum is the most effective soil amendment for removing sodium from the soil. It is a slightly soluble salt of calcium and sulfate. Gypsum will react with the sodium in the soil very slowly but for a long period of time.

The amount of gypsum required varies depending on the percent of exchangeable sodium and soil texture. **See Table 1**.

Table 1

Soil Texture	**Exchangeable Sodium**				
	15	**20**	**30**	**40**	**50**
	Tons per acre Gypsum				
Coarse	2	3	5	7	9
Medium	3	5	8	11	14
Fine	4	6	10	14	18

Incorporate the gypsum to a depth of only 1 or 2 inches in the soil. It should be mixed well enough with the soil to keep it from blowing away.

When the application of gypsum exceeds 5 tons/ac, the rate should be split into two or more applications of no more than 5 tons per application. Successive applications should not be made until some time has allowed for leaching to occur (1 year) and a second soil test verifies the need for the additional application of gypsum.

Tillage and Planting of Saline and Alkali Soils

Inversion type tillage, such as moldboard plowing, should be avoided for several years to promote uninterrupted leaching of the salts through the soil profile. Inversion tillage brings soil and salts from the depth of tillage up to the soil surface and starts the leaching process over again. Avoid tillage when the risk for compacting the soil is high on problem areas.

When the salt level in the soil has been reduced adequately, a salt tolerant crop or forage can be established on the problem area. It is especially important to have a crop or cover on the soil surface during the summer when evaporation is high. The surface should be kept covered as much as possible to keep moisture from evaporating and groundwater from wicking to the surface bringing up salts. **Tables 2 and 3** contain crops and forages and their salt tolerances.

Grass plantings will be done according to the Oklahoma NRCS Critical Area Planting (342) standard and specification. See **Table 2** for grass species to use on these sites. Plant species that can establish in the existing salinity.

Use soil testing to avoid applying excess fertilizer. Fertilizers contain salts and if applied in excess can add to the problem. Apply fertilizer according to the Oklahoma NRCS Nutrient Management (590) standard and specification for critical area plantings.

Additional Criteria Specific to Saline Seeps and Their Recharge Areas

Identifying Saline Seeps

Saline seeps are intermittent or continuous saline water sites that discharge at the soil surface. They occur downslope from a recharge area.

Saline areas will develop white crusts on the soil surface as water evaporates from the soil profile during dry periods. Normal crop growth is inhibited due to the salt concentration in the plant root zone. Seed germination and early seedling stages are particularly effected.

Saline soils will have a very good physical condition throughout the tillage zone. The soil will be friable, mellow, and easily tilled. Soil which has been saline for several years is generally very fertile having high N, P, and K soil analysis. These nutrients tend to build up due to the lack of vegetation grown on the site.

Determination of Saline Seeps

Saline seeps shall be evaluated in one of the following ways:

- A soil scientist will evaluate the site with a salinity meter

  or
- Soil samples will be taken and tested for salinity at the Oklahoma State University soils lab or any other soils lab using the same testing procedures and approved through the North American Proficiency Testing Program.

The size of the recharge and seep area will be determined by a soil scientist and delineated on an aerial map. Recharge areas are generally within 2000 ft. of the saline seep.

Soil samples will be collected in accordance with OSU Fact Sheet 2207 – How to Get a Good Soil Sample. A salinity management analysis will be done on the soil sample. This analysis includes results for Na, Ca, Mg, K, B, Electrical Conductivity (EC), Total Soluble Salts (TSS), Sodium Adsorption Ratio (SAR), Exchangeable Sodium Percentage (ESP), and pH. It is best to sample during a dry period of the growing season and should be taken at least one week after the last rain. Samples should only be taken from the top 1 to 3 inches of soil (seeding depth).

Saline seeps have the following characteristics:

- They have been accelerated by dryland farming practices
- They are recent and local in origin
- They develop a white crust on the soil surface
- The water table is within 8 feet of the soil surface (often within 3 ft. of the soil surface)
- Soil Electrical Conductivity (EC) is greater than 4 mmhos/cm at 25^{o}C in the top 6 inches of soil. The soil EC will decrease with soil depth.
- Soil pH is less than 9
- Groundwater salinity is generally 4000 micromhos or greater (2600 ppm soluble salts)

Management of the Recharge Area

Saline seeps are caused by water escaping the plant root zone in the recharge area and moving downslope until surfacing.

Plant and maintain adapted high water use vegetation in recharge areas to utilize soil water before it escapes the root zone. At least 80% of the recharge area should be planted to perennial vegetation.

Grass plantings done in recharge areas will be done according to the Oklahoma NRCS Pasture Planting (512) and Range Planting (550) standards and specifications.

Apply fertilizer according to the Oklahoma NRCS Nutrient Management (590) standard and specification for grass plantings.

Where practical, divert run-on water and/or install surface and/or subsurface drainage to minimize water infiltration and decrease soil water in recharge areas.

Management of Saline Seep Area

Plants that produce satisfactory yields under the existing salinity should be used in the seep area.

Adapted vegetation may be established in saline seep areas at the same time as the recharge area, however, it is best to delay planting until water tables have been lowered sufficiently to prevent capillary movement of water and salts into the root zone and to the soil surface.

Grass plantings in saline seep areas will be done according to the Oklahoma NRCS Critical Area Planting (342) standard and specification.

See **Table 2** for species to use in saline seep areas.

Apply fertilizer according to the Oklahoma NRCS Nutrient Management (590) standard and specification for critical area plantings.

CONSIDERATIONS

Soil salinity levels can be monitored to minimize the effects of salinity on crops and to evaluate management practices.

Tools such as electromagnetic induction (EMI) and salinity probes are appropriate for evaluating and for monitoring soil salinity levels.

The drainage water from this practice may have high levels of salts. Select an outlet or disposal area that will minimize the effects of this saline water.

Removal of salts from the root zone by leaching operations may increase contamination of water tables. Avoid excessive leaching, and schedule leaching operations during seasons when potential contaminants in the soil profile, such as nitrogen, are low.

For irrigated conditions, an irrigation water management plan should minimize nonpoint pollution of surface and groundwater resources.

Polyacrylamides may improve effectiveness of leaching and reclamation of some soils.

Water of slight to moderate salinity, not dominated by sodium, can enhance leaching of salts.

Residue management can improve the organic matter content of the soil, improve infiltration and minimize surface evaporation and capillary rise of salts to the soil surface.

Consider using bedding and planting methods designed to reduce salinity near plant root zone, especially for germinating seeds.

PLANS AND SPECIFICATIONS

Specifications for establishment and operation of this practice shall be prepared for each field or treatment unit according to the Criteria, Considerations, and Operation and Maintenance described in this standard. Specifications shall be recorded using approved specification sheets, job sheets, narrative statements in the conservation plan, or other acceptable documentation.

OPERATION AND MAINTENANCE

No operation and maintenance requirements, national in scope, have been identified for this practice.

REFERENCES

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California Fertilizer Association. 1998. Water and plant growth. p. 21–66. *In* Western Fertilizer Handbook. Interstate Publishers, Inc., Danville, Illinois.

Rhoades, J.D., and J. Loveday. 1990. Salinity in Irrigated Agriculture. p. 1089–1142. *In* B.A. Stewart and D.R. Nielsen (ed.), Irrigation of Agricultural Crops. Agron. Monogr. 30. ASA, CSSA and SSSA, Madison, WI.

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References: "Saline Seep Diagnosis, Control and Reclamation", USDA – Agricultural Conservation Report No. 30, P. L. Brown, A. D. Halvorson, F. H. Siddoway, H. F. Mayland, and M. R. Miller, 1982

OSU Extension Fact Sheet F-2226, "Reclaiming Slick-Spots and Salty Soils

TABLE 2

Salt Tolerances of Permanent Vegetation

Species	Maximum EC for Establishment [1/]	Maximum EC without Yield Loss [2/]	Maximum Tolerable EC of Established Plants [3/]	Water Use (in/yr) [4/]	Rooting Depth (feet) [4/***]
Tall Wheatgrass	26	7.5	32	26*	3 - 5
Bermudagrass	26	6.9	23	35	3 - 5
Alkali Sacaton	20	**	**	**	3 - 5
Tall Fescue	20	3.9	23	26*	3 - 5
Western Wheatgrass	18	**	22	**	3 - 5
Switchgrass	10	**	19	26	3 - 5
Alfalfa	8	2.0	16	45	5 - 8
Native grass mixture	5	**	**	**	3 - 5

EC = Electrical Conductivity (mmho/cm at 25°C)

*Estimated water use

**No data available

***Depth at which 80% of the roots are available for water uptake in soils with no root restrictions.

[1/] Montana Plant Materials Technical Note No. 26 - 1981

[2/] Saline and Sodic Soils – Breasler, et.al 1982, NRCS National Engineering Handbook – Part 623, Chapter 2, Table 2-34

[3/] Crop Water Requirements, Irrigation and Drainage Paper, J Doorenbos et.al

[4/] National Engineering Handbook, Part 652, Irrigation Guide, Chapter 3, Table 3-4 and Tables OK-4-1 through 11

TABLE 3

Salt Tolerances of Annual Crops

Species	Percent of Yield Reduction as EC Increases[1/]					Maximum EC without Yield Loss[1/]	Maximum Tolerable EC of Established Plants[2/]	Water Use (in/yr) [3/]	Rooting Depth (feet)[3/*]
	EC 4	EC 8	EC 12	EC 16	EC 20				
Barley	100%	100%	80%	60%	40%	8.0	28	14	3 - 5
Cotton	100%	98%	78%	57%	36%	7.7	27	26	4 - 6
Wheat	100%	86%	57%	29%	**	6.0	20	16	3 - 5
Soybeans	100%	40%	0%	**	**	5.0	10	24	3 - 4
Grain Sorghum	100%	78%	50%	22%	**	6.8	18	26	3 - 5
Peanut	77%	**	**	**	**	3.2	7	18	3 - 4
Sudangrass	95%	78%	61%	43%	**	2.8	26	28	3 - 5
Corn	84%	54%	24%	**	**	1.8	10	31	3 - 5

EC = Electrical Conductivity (mmho/cm at 25°C)

*Depth at which 80% of the roots are available for water uptake in soils with no root restrictions.

**No data available

[1/] Saline and Sodic Soils – Breasler, et.al 1982, NRCS National Engineering Handbook – Part 623, Chapter 2, Table 2-34

[2/] Crop Water Requirements, Irrigation and Drainage Paper, J Doorenbos et.al

[3/] National Engineering Handbook, Part 652, Irrigation Guide, Chapter 3, Table 3-4 and Tables OK-4-1 through 11