Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

SALINE AND SODIC SOIL MANAGEMENT

CODE 610

(ac)

DEFINITION

Management of land, water, and plants to reduce the accumulation impacts of salts, sodium, or combination of salts and sodium on the soil surface and in the rooting zone.

PURPOSE

This practice is used to accomplish one or more of the following purposes:

- Reduce salt concentrations in the root zone
- Reduce problems of crusting, permeability, or soil aggregate stability on sodium-affected soils
- Reduce salts transported to surface water
- Reduce soil salinization or discharge of saline water tables at or near the soil surface downslope from saline seep recharge areas
- Improve plant productivity and health
- Mitigate air quality or wind erosion effects derived from saline or sodic soils

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all land uses where one or more of the following conditions exist:

- The concentration or toxicity of salt limits the growth of desirable plants
- Excess sodium causes crusting and permeability problems
- Saline seep recharge and discharge areas
- Where sparsely vegetated areas with saline or sodic soils are causing wind erosion concerns

CRITERIA

General Criteria Applicable to All Purposes

Alleviate localized ponding that persists for more than 24 hours after irrigation or precipitation events by improvements to drainage or improved soil physical properties that reduce ponding.

In noncrop areas, manage soil surfaces with salt-tolerant vegetation and land shaping practices to reduce wind speeds at the soil surface.

Additional Criteria Applicable to Reduce Salt Concentration in the Root Zone

Map the land unit using electromagnetic induction or other appropriate method to determine location and level of salts measured as electrical conductivity (EC). Include the salinity levels to the depth of the active root area of the desired plants on the final map.

Base the suitability of water for leaching on a representative water quality test report that includes EC, sodium adsorption ratio (SAR), and hydrogen ion concentration (pH), as well as the concentrations of the following individual constituents: calcium, magnesium, sodium, and sulfate concentrations. If EC is not reported, total dissolved solids may be used to estimate EC.

Base the volume of applied water on salinity map, leaching method (i.e., sprinkler, continuous flood, etc.) and percent of salt to be removed. Apply leaching water until desired salinity level is met.

In areas where additional drainage is needed to facilitate the leaching process, provide the additional drainage by subsoiling or by installing permanent surface or subsurface drainage. Based on soil properties, subsoiling may be a temporary solution and some cases may need to be repeated. For added drainage measures, follow criteria in NRCS Conservation Practice Standards (CPSs) Subsurface Drain (Code 606); Surface Drain, Field Ditch (Code 607) or Surface Drain, Main or Lateral (Code 608); or Deep Tillage (Code 324), as applicable.

After the desired salinity level is reached, use water quality test, crop salinity thresholds of desired crop, and methods in the NRCS National Engineering Handbook (NEH) (Title 210), Part 623, Chapter 2, “Irrigation Water Requirements,” to determine the leaching fraction that is required to maintain root zone salinity and sodium levels within acceptable levels after reclamation.

In lieu of 210-NEH-623-2, the following may be used to determine leaching requirements:

- Analytical Steady-state Solutions for Water-limited Cropping Systems Using Saline Irrigation Water (Skaggs et al., 2014).
- Leaching Requirement for Soil Salinity Control: Steady-state versus Transient Models (Corwin et al., 2007).

Additional Criteria to Reduce Problems of Crusting, Permeability, or Soil Structure on Sodium-Affected Soils

Take soil samples representing each quarter (with depth) of the root zone. For example, if the root zone is 4 feet deep, take soil samples representing depths of 0-12 inches, 12-24 inches, etc.). Analyze soil samples to obtain EC; pH; cation exchange capacity; SAR; and ion concentrations of sodium, calcium, magnesium, and sulfate-sulfur. Determine ion concentrations from a saturated paste extract. Local conditions may indicate the need for more comprehensive soil tests (e.g., potassium and potentially toxic ions).

Plant salt-tolerant cover crops with fibrous roots to improve soil structure. Establish vegetation by preparing the site to a consistent seeding depth. Eliminate weeds that would impede the establishment and growth of selected species. Apply nutrients as needed to ensure crop establishment and planned growth. Incorporate cover crops to increase water infiltration and permeability.

Base the need for soil amendments to treat sodium-affected soils on the SAR of the soil water extract from the depth of the root zone to be treated. If the lab reports exchangeable sodium percentage (ESP) it may be used in lieu of SAR. Apply soil amendments that cause replacement of adsorbed soil sodium by calcium. Base application rates for soil amendments on SAR and/or ESP soil test results, the purity of the applied amendment, and quality of the irrigation water.

Once the calcium amendment (e.g., gypsum) is applied and incorporated, use good quality water to leach the displaced sodium beyond the root zone. Base the volume of applied water on method of application (e.g., sprinkler, intermittent flood, etc.), crop requirements, leaching fraction, and desired sodic level. Apply leaching water until desired sodic level is met. See 210-NEH-623-2, Section 623.0205(f)(3), “Reclamation of sodic soils.”

In areas where additional drainage is needed to facilitate the leaching process, the additional drainage will need to be provided by subsoiling or the installation of permanent surface or subsurface drainage. Based on soil properties, subsoiling may be a temporary solution and some cases may need to be repeated. For

added drainage measures follow criteria in NRCS CPSs Subsurface Drain (Code 606); Surface Drain, Field Ditch (Code 607) or Surface Drain, Main or Lateral (Code 608); and Deep Tillage (Code 324) as applicable.

Additional Criteria for Saline Seeps and Their Recharge Areas

Apply the following measures to reduce subsurface water and salt movement to the seep outlet:

- Establish deep-rooted, long-season, or perennial species in the recharge watershed area to utilize soil moisture and limit ground water movement to the seep area.
- Remove ponded surface water from the recharge area before it percolates below the root zone.
- Where practical, accomplish revegetation of the saline seep discharge area with species adapted to utilize excess soil moisture and to prevent upward movement of water causing salt depositions. Reference NRCS National Agronomy Manual (NAM) (Title 190), Part 504, Section 504.06(d) “Management practices for control of saline seeps.”

Establish vegetation by preparing the site to a consistent seeding depth. Eliminate weeds that would impede the establishment and growth of selected species. Apply nutrients as needed to ensure crop establishment and planned growth.

CONSIDERATIONS

When planning this practice, the following items should be considered where applicable:

- Tools such as electromagnetic induction, salinity probes (e.g., four electrode Wanner array), EC instruments, and field soil test kits are appropriate for evaluating and for monitoring soil salinity levels.
- Representative water chemistry reports for surface water sources may be available from U.S. Geological Survey or from water districts.
- Consult published data for crop salt tolerances and specific ion toxicities of crops for crop recommendations. (Refer to 190-NAM-504, Table 504-6, and 210-NEH-623-2, Section 623.0205, Table 2-34.)
- Sulfur or sulfuric acid applications enhance conversion of naturally occurring calcium carbonate to more soluble gypsum. Leaching should be delayed until the sulfur has oxidized and gypsum has formed.
- Monitor gypsum accumulation on the soil surface and subsurface to avoid creation of gypsiferous soil conditions that can occur from—
    - Applying irrigation water high in calcium and sulfate,
    - Overapplication of gypsum,
    - Leaching of saline soils that containing sulfate and calcium into subsoil,
    - Runoff water high in calcium and sulfate, or
    - Other sources of sulfate and calcium.
- Seasonal changes in source water quality may require water quality evaluations at several times during the season of use.
- Drainage water discharges may have high concentrations of salt. Select appropriate outlets and consider effects of discharges to surface and ground water.
- Subsoiling for improvement of internal soil drainage may not be effective in soils of uniform texture/permeability or if soils are not dry during subsoiling operations.
- Avoid inversion tillage that can bring salinity to the surface and negate the leaching process.
- Use of green manure crops, cover crops, mulch, or other sources of organic matter can improve soil structure and permeability.
- Salt-tolerant crops with vigorously-growing, fibrous root systems (e.g., sorghum, Sudan grass) can

increase the carbon dioxide content of the soil water, increasing the solubility of calcium carbonate to facilitate leaching of sodium.

- Water of slight to moderate salinity not dominated by sodium can be more effective than water of low salinity for leaching of salts.
- Crop 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.
- Applying salinity-laden irrigation water with sprinkler or microsprays can cause foliar damage.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for establishment and operation of this practice for each field or treatment unit according to the criteria described in this standard. As applicable, include—

- Plan map showing location of—
  - Salinity/sodium-affected areas.
  - Saline seep recharge areas.
  - Saline seep outlets or discharge areas.
  - Drainage system to be installed.
  - Area where soil amendments are to be applied.
  - Area where vegetation is to be established.
- Required soil and water tests.
- Requirements for application of soil amendments.
- Requirements for establishment of vegetation.
- Drainage system details, including conduit lengths, grades, sizes, materials, constructed channel dimensions, and all appurtenances.
- Leaching requirements for specific soils and crops, including the method and timing of water application.
- Crop management measures to be utilized for specific soils and crops to include irrigation management, cover crops, crop rotations, tillage systems, perennial crops, nutrient management , and other management measures needed to manage salinity.

OPERATION AND MAINTENANCE

Provide a site-specific operation and maintenance plan to the landowner or operator prior to implementing the practice. Include guidance in the plan for the routine maintenance and operational needs of the affected area and any structural measures installed in conjunction with this practice.

REFERENCES

Corwin, D., J. Rhoades, and J. Simunek. 2007. Leaching Requirement for Soil Salinity Control: Steady-state versus Transient Models. Agricultural Water Management 90:165-180. https://doi.org/10.1016/j.agwat.2007.02.007

Hoffman, G. 1985. Drainage Required to Manage Salinity. Journal of Irrigation and Drainage Engineering: Vol. 111, Issue 3. https://doi.org/10.1061/(ASCE)0733-9437(1985)111:3(199)

Richards, L. (ed.). 1954. Diagnosis and Improvement of Saline and Alkali Soils. Agricultural Handbook No. 60. USDA Agricultural Research Service, Soil and Water Conservation Research Branch. Washington, D.C. https://www.ars.usda.gov/ARSUserFiles/20360500/hb60_pdf/hb60complete.pdf

Skaggs, T.H., R.G. Anderson, D.L. Corwin, and D.L. Suarez. 2014. Analytical Steady-state Solutions for Water-limited Cropping Systems Using Saline Irrigation Water. Water Resources Research 50:9656-9674. https://doi.org/10.1002/2014WR016058

USDA NRCS. 1993. National Engineering Handbook (Title 210), Part 623, Chapter 2, Irrigation Water Requirements. Washington, D.C. https://directives.sc.egov.usda.gov/

USDA NRCS. 2011. National Agronomy Manual (Title 190), Part 504, Water Management, Sections 504.06 and 504.07. Washington, D.C. https://directives.sc.egov.usda.gov/

Wallender, W. and K. Tanji (eds.). 2012. Agricultural Salinity Assessment and Management: Manual of Practice, Second Edition. Manual of Practice 71, American Society of Civil Engineers. Reston, VA. https://doi.org/10.1061/9780784411698