NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE SPECIFICATION GUIDE SHEET

SALINITY AND SODIC SOIL MANAGEMENT

(Ac.)

PRACTICE CODE 610

What is Saline and Sodic Soil Management?
Saline and Sodic Soil Management is the management of land, water and plants to control and minimize accumulations of salts and the effects of sodium in the rooting zone.

How it helps: The practice is intended to improve soil health or plant productivity, or to convert unproductive cropland to suitable permanent vegetation. Where salinity problems are human-induced, the practice is intended to halt or reverse the adverse movement of salts due to excess groundwater or a perched water table. The practice can also help reduce soil crusting and improve permeability caused by sodic soils.

In addition to treating areas adversely affected by salts or sodium, this practice is also applicable to treating saline seep recharge areas. In a recharge area, rain water or snow melt, in excess of the water holding capacity of the soil moves below the root zone transporting soluble salts in the process. Water moves downward until a less permeable layer is encountered, which then causes the water to move laterally, carrying with it, the dissolved salts which eventually discharge near the soil surface. The result is usually continuous surface wetness and an accumulation of soluble salts. Use of an improved water management system in the recharge area reduces this condition.

To apply this practice: The problem area must first be identified and delineated. Soils should be examined where salts are visible on the surface, vegetation is predominantly salt-tolerant, or vegetative growth is absent.

Visual observations provide clues that aid in identifying the problem as plants are often stunted or absent. Use of hand-held electrical conductivity meters also aids in identifying salinity problems. However, soil sampling is the best way to assess the type of problem that exists. Soil salinity and/or sodicity issues may be masked when soils are wet or tilled.

Sampling Method: Divide the problematic area into zones based on soil map units, visual observations, LiDAR or topography maps, and/or history of plant stands or crop yields. Each zone sample should consist of 8 to 10 soil cores to accurately represent the zone. Using GPS to sample these points will improve post treatment soil test consistency. A minimum of 2 zones must be sampled. One inside and one outside the affected area. Sampling zones aid in determining if multiple strategies are needed to address reclamation of the site. Mixing samples from areas that are not similar will not reflect the true characteristics of the area. Utilize soil surveys to identify possible inclusions not mapped separately.

Sampling Depth: Soil samples collected from the 0 to 3 inch depth for use with a hand-held EC meter may be useful in identifying salinity-affected patterns. To determine salt concentrations in the root zone and the type of ions involved, it is recommended that a 0 to 6 inch and 6 to 24 inch soil sample be collected. In some instances a 2-foot sampling depth is not enough. If tiling is being considered, it is recommended that samples be collected to a depth below the planned tile line. In this case, samples are typically collected to a 4 foot depth. Recommended sample depths can be adjusted in consultation with a NRCS soil scientist following a geologic investigation. There is often resistance to adequate soil testing because of the cost involved. Analytical costs represent a minimal percentage of the total cost of reclamation.

Minimum Soil Test Analysis Requirements: Soil test analysis must include at a minimum, soluble salts (EC), sodium (SAR, ESP, or % Na^+), pH, and sulfur for the 0-6” and 6-24” depth inside and outside the affected area.

Methods of Analysis: Different labs use different methods to analyze soil samples to assess soluble salt and sodium levels. For salts, the basic test needed to determine the levels of soluble salts is Electrical Conductivity (EC). EC values are measured with a 1:1 soil-to-water slurry or a saturated paste method. Many laboratories, prefer the 1:1 soil to water slurry over the saturated paste method because it is easier and less expensive to use. However, the EC values from the two techniques are not equivalent, with the 1:1 method having a much lower value. To convert from the 1:1 method to the saturated paste equivalent (EC_e), South Dakota NRCS uses a conversion factor of 1.6. The relationship between EC_e and $EC_{1:1}$ are very good, however, different publications suggest different correlation factors. This appears to be due to differences in parent material. For most agronomic purposes, multiplying the $EC_{1:1}$ by the 1.6 conversion factor will adequately indicate the level of salts present. In those situations where it is felt the conversion is not predicting the EC level correctly, the EC_e method should be used.

For sodium, the extent of soil sodicity is usually measured either through its Exchangeable Sodium Percentage (ESP) or Sodium Adsorption Ratio (SAR). Both measure the sodium (Na^+) content of the soils in relation to calcium (Ca^{2+}) and magnesium (Mg^{2+}). SAR describes the proportion of Na^+ to Ca^{2+} and Mg^{2+} in soil solution and ESP measures the Na^+ adsorbed on soil particles as a percentage of the Cation Exchange Capacity (CEC). A third method used by NDSU, substitute’s %Na for SAR.

If soil amendments are being considered, the Cation Exchange Capacity (CEC) test will also be required. Other tests that help in developing a remediation strategy include soil pH, chloride (Cl^-), sulfate (SO_4^{2-}) carbonates (CO_3^{2-}) and bicarbonates (HCO_3^-).

Interpreting Soil Analysis Results:

Saline
pH < 8.4
EC > 4 mmhos cm^{-1} Saturated Paste
SAR < 13, ESP < 15%

Sodic
pH > 8.4
EC < 4 mmhos cm^{-1} Saturated Paste
SAR > 13, ESP > 15%

Saline-Sodic
pH < 8.4
EC > 4 mmhos cm^{-1} Saturated Paste
SAR > 13, ESP > 15%

Note: pH listed is typical. These values may vary and are meant as general guidelines.

SALTS AND SODIUM:

Salt Level in Soil, Electrical Conductivity (EC_e)

Low	Medium	High	Very High
. . . . .dS/m or (mmhos)/cm.			
< 3	3 - 5	5.1 - 10.0	> 10

Sodium Level in Soil, Exchangeable Sodium Percentage (ESP)

Low	Medium	High
. . . .Exchangeable sodium percentage (ESP). . . .		
< 9	9 - 13	> 13

Source: Fertilizer Recommendations Guide (EC750):

Managing High Salts: Soil salinity is strongly linked to water movement through the soil profile. When sub-soil moisture, containing salts, moves upward and evaporates, salts are precipitated at or near the soil surface thereby inhibiting seed germination and plant growth. If salinity is not severe enough to significantly reduce yields, implementing practices which prevent further salinization and managing soils "as is" with salt-tolerant crops or different land uses may be the best choice. Using salt tolerant cover crops to shade the soil and leaving crop residues on the soil surface, which reduce high soil temperatures that increase evaporation rates and damage soil microbial communities is also a good option.

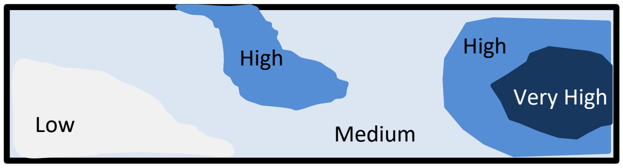
Crop salt tolerance ratings:

Tolerant (T)		Moderately Tolerant (MT)		Moderately Sensitive (MS)	
Sat. Paste (dS/m)		Sat. Paste (dS/m)		Sat. Paste (dS/m)	
Barley	8	Safflower	-	Alfalfa	2
Canola or Rapeseed	11	Sorghum	6.8	Chickpea	-
Rye (forage)	7.6	Soybean	5	Corn	1.7
Sugar beet	7	Sudangrass	2.8	Cowpea	2.5
Triticale	6.1	Sunflower	4.8	Crambe	2
Wheat, Durum	5.9	Sweet clover	-	Flax	1.7
		Wheat	6	Millet	-
				Oat*	2.4
				Radish	1.2
				Turnip	0.9

Source: Annex 1. Crop salt tolerance data
*Source: The Management and Identification of Saline and Sodic Soils in the Northern Great Plains

Relative tolerance ratings for perennial plants: Utilize the USDA PLANTS Database PLANTS Characteristics or Range Technical Note No. 4; Table 3. Species Characteristics, for salt tolerance ratings. A link to the PLANTS database is located in the TOOLS box of the Seeding Plan labeled Show Species/Variety Characteristics. A link to Range Technical Note No. 4 is located in the SEEDING PLAN near the (4) Site box. Recognize that considerable variation in seed germination within species has been documented.

Management Strategies for Managing EC_e Levels: It is important to understand that within an individual field there may be different levels of salinity. The conservation practice(s) selected in addition to the 610 standard to manage a very high EC_e area may be different than the conservation practices selected to manage a medium or high EC_e area.



Medium - Sensitive plants will show injury.

- Expected soil recovery period of 1 to 3 years.
  - Conservation Crop Rotation - 328
    - Include late-maturing and deep rooted crops in the rotation. Eliminate bare summer fallow. Additional benefits can be obtained by increasing rotation diversity to 3 or more crops.
  - Cover Crop – 340
    - Seeding cover crops after short season and low residue crops utilizes excess moisture and helps prevent evaporation so salts don't move to the surface.
  - Residue Management, Reduced till – 345 or No till 329
    - Maintain a minimum of 30% - 50% residue to help reduce surface evaporation. If tillage is used, shallow tillage rather than deep tillage helps reduce the amount of salts returned to the soil surface.

High - Non-salt tolerant plants will show injury.

- Expected soil recovery period of 5 years or more.
  - Conservation Crop Rotation – 328
    - Add crops with high salt tolerances to the rotation and continue to increase rotation diversity. Salt-tolerant alfalfa varieties have better germination in saline conditions, however seed costs are significantly higher. Consider growing grasses on this land.
  - Cover Crop – 340
    - Seed salt tolerant cover crops after short season and low residue crops to utilize excess moisture and help prevent evaporation so salts don't move to the surface.
  - Residue Management, No till – 329
    - Consider eliminating tillage. Connected, intact pores protected by surface residue allow water drainage. Salts leached away by winter snow melt and spring rains can be returned to the surface with deep spring tillage.

Very High – Only salt tolerant plants will grow.

- Expected soil recovery 10 years or more.
  - Perennial Vegetation Establishment Recommended
    - Perennial sod forming grasses use more water which then lowers the EC in adjacent areas and allows the perennial grass to move further into the affected area. It also lowers the water table and allows salts to leach lower in the soil profile. Total reclamation of saline soil is a long-term process. Removal of perennial vegetation without good soil and water management strategies will negate the effects previously achieved.

Managing High Sodium: Just as crops differ in tolerance to high salt concentrations, they differ in their ability to withstand high sodium concentrations. Generally, soybeans are more sensitive, sunflowers, corn and grain sorghum are intermediate and wheat and alfalfa are more tolerant. Crop growth and development problems on sodic soils is typically due to poor physical conditions of the soil or an accumulation of sodium in plants. It is important to be aware that sodic soils are typically irregular and jagged in shape and are complex in nature or made up of more than one soil map unit resulting in a range of sodicity within an area.

Perennial vegetation and cover crop establishment: Research has shown that the optimum period to complete seedings for forage and cover crop species in wet saline and/or sodic soils is late fall (mid-October - December) or as a dormant seeding. The seed should be in the ground before the next growing season so that it can take advantage of the diluting effect of early spring moisture on salt concentrations. Seedbed preparation is critical. Tillage on soils high in salinity may not be possible, or may not provide the best seedbed. Chemically controlling weeds prior to planting will allow soil structure to remain intact thereby improving moisture infiltration and reducing surface evaporation.

Treatment Methods:
Seeding: The most common treatment method for this practice is establishing and maintaining permanent herbaceous vegetation. Permanent herbaceous plantings shall be designed and installed in accordance with one of the following Practice Standards located in Section IV of the Field Office Technical Guide:

Conservation Cover - 327
Range Planting – 550
Forage and Biomass Planting – 512
Wildlife Upland Habitat Management – 645
Critical Area Planting - 342 (where erosion or other conditions are unusually adverse including strongly saline soils)
Mulching – 484 (consider use if the soil is bare after planting to reduce salt accumulation at the soil surface which aids in germination and seedling survival)

Amendments: Most soils in SD contain gypsum in their soil profile. If soils are acidic or have a low pH, the hydrogen ion (H+) is most likely the principal cause due to additions of nitrogen-containing fertilizers. Lime is the correct amendment to address soil acidity in SD. Gypsum has been recommended in other states for sodium affected soil remediation. SD Extension & Research staff have not verified or demonstrated successful use of gypsum for sodium affected soil at this time. Therefore, increasing organic matter levels by continuous cropping (no fallow periods), minimizing tillage, establishing tolerant plant species, and removing excess water is a more sustainable approach to reducing the effects of sodic soil. Additional information can be obtained from SF-1321 Effectiveness of Gypsum in the North-central Region of the U.S.

Drainage: To treat saline areas ONLY, artificial drainage may be used to remove excess ground water and accompanying salts. Salts can be leached out of the soil if the soil is deep, permeability is good and there is no water table near the surface. A good water source and good soil drainage are necessary for effective salt leaching. An acceptable outlet for the saline water, which does not adversely impact water quality needs to be identified. This approach should be used judiciously due to cost. Refer to conservation practice Subsurface Drain – 606 and comply with applicable local, State, Tribal, and Federal drainage regulations and ensure compliance with wetland rules and regulations.

Maintaining the Practice: Despite the best water table management, excessive rainfall could raise the water table close to the surface. However, the chances of this are lower if the water table is initially lower. Lowering the water table should be viewed as a long-term management tool, and not a quick nor permanent renovation technique. Fields planted to permanent vegetation for this practice need to be managed according to a site-specific plan. Long-term maintenance is achieved with management practices such as Forage Harvest Management – 511, Prescribed Grazing – 528, Wildlife Upland Habitat Management – 645, or Conservation Crop Rotation – 328.

Programmatic Guidance: Continuous Conservation Reserve Program (CCRP) – Utilize Conservation Practice Standard 327 to establish permanent salt tolerant vegetative cover on areas with either saline seep areas (CP18B) or on areas with existing high water tables (CP18C). A hand-held EC meter may be used to determine eligibility. A soil test is not required.

Environmental Quality Incentives Program (EQIP): The salinity and sodic soil practice standard (610) acts as the umbrella under which reclamation occurs and includes the management, labor, education and monitoring that needs to occur during the reclamation process. Appropriate practice standards for the vegetative (or other) methods utilized to reclaim the site will be selected to treat the problem. Perennial vegetative cover would be required in areas that exceed the thresholds for annual crop production. An entire field would not necessarily receive the same treatment, but the entire field needs treated to receive a payment.

NRCS staff can use hand-held EC meters, if available, to assist the producer in identifying salinity affected areas. The 610 standard requires a previous soil test to evaluate the effectiveness of the planned treatment and need for revision. If the producer has a previous or historic soil test that can be utilized, make a copy and include it in the contract folder. If not, a soil test will need to be collected prior to implementing the treatment.

The 610 payment is based on contracted acres receiving treatment and may include the whole field. The annual payment will be initiated once the practice has been implemented and can continue up to a period of 3 years. Regardless of whether the treatment method selected is perennial vegetation or appropriate annual crops/cover crops, each year 610 is scheduled in a contract, a soil test will be required both inside the seep area and outside the seep area to monitor effectiveness.

In some situations it would be appropriate to schedule 610 for less than 3 years. However, it is not appropriate to not schedule 610 one year of the crop rotation because the producer wants to plant a crop not suited to the site that doesn't meet the intended management requirements to address the problem.

Conservation Stewardship Program: The 610 practice standard may be planned to meet a resource concern not met at the time of application or can be planned on a resource concern cause that is already met if it increases the level of conservation on the land. Requirements to receive a payment will follow the EQIP guidelines listed above with the exception that the annual payment will be initiated once the practice has been implemented and will continue for a period of 5 years. There are no enhancements associated with this practice.

References:

Annex 1. Crop salt tolerance data
Natural Resources Management and Environment Department

Gypsum Misconceptions - https://www.igrow.org/agronomy/corn/gypsum-misconceptions/
SDSU Extension

iGrow Corn: Best Management Practices, Chapter 32 - The Management and Identification of Saline and Sodic Soils in the Northern Great Plains, SDSU Extension - http://igrow.org/up/resources/03-5000-2016-32.pdf

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Malo, D. D., Clay, D.E., Reese, C.L., Clay, S.A., Owen, R., Kharel, T., Birru, G., Green, J., DeSutter, T.M. (2015) Saline and Sodic Soils: Characteristics and Properties. Retrieved from http://sdcorn.s3.amazonaws.com/content/uploads/2015/09/1_Salinity-Field-Days-Malo.pdf

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New Life for Saline Soil. Retrieved from http://www.agriculture.com/crops/cover-crops/new-life-for-saline-soil on 3/24/2017.
Plant Materials for Salt-Affected Sites in the Northern Great Plains

USDA – Natural Resources Conservation Service- Bismarck, North Dakota

Plants for Saline to Sodic Soil Conditions; Technical Note No. 9A, Revised February 2010
USDA – Natural Resources Conservation Service – Boise, Idaho – Salt Lake City, Utah

Salinity and Sodic Soil Management Fact Sheet, March 2005
USDA – Natural Resources Conservation Service – North Dakota

Soil Testing Unproductive Areas
NDSU Extension Service – SF1809; SF1809, Soil Testing Unproductive Areas

Worcester, B.K., L.J. Brun and E.J. Doering,, Classification and Management of Saline Seeps in Western North Dakota, Retrieved from
http://library.ndsu.edu/tools/dspace/load/?file=/repository/bitstream/handle/10365/9727/farm_33_01_01.pdf?sequence=1

Appendix A: EC Conversion Factor

The factor used to convert EC from the 1:1 soil-to-water mixture to a saturated paste equivalent was derived by interpolating between the conversion factors identified in Smith and Doran, SSSA 49:169-185 for coarse (2.0) and fine (1.4) textured soils to establish a value of 1.8 to represent soils finer than coarse (sand). The median between clay (1.4) and sand (1.8) was calculated to represent silt (1.6). A representative average (conversion factor) was then calculated using the assigned indexes: EC 1:1 conversion factor = (1.4+1.6+1.8)/3

Appendix B: Example Seeding Mixes for EC_e Levels in the High or Very High Category.

Mix 1

Seed Species	Variety	Percent in Mixture
Tall wheatgrass	Common	25
Creeping foxtail	Garrison	20
Alfalfa	Salinity max	15
Green wheatgrass	AC Saltlander	20
Intermediate wheatgrass	Common	20

Mix 2

Seed Species	Variety	Percent in Mixture
Alfalfa	Salinity Max	10
Creeping foxtail	Garrison	10
Western wheatgrass	Rosana	30
Tall wheatgrass	Alkar	30
Green wheatgrass	AC saltlander	10
Intermediate wheatgrass	Ohae	10

Mix 3

Seed Species	Variety	Percent in Mixture
Western wheatgrass	Rosana	25
Tall wheatgrass	Alkar	25
Green wheatgrass	AC Saltlander	50

Mix 4

Seed Species	Variety	Percent in Mixture
Creeping foxtail	Garrison	15
Slender wheatgrass	Common	20
Green wheatgrass	AC Saltlander	85*

*Mix exceeds 100%. Additional seed may not be cost-shareable.