There must be enough irrigation water available so that the excess salts can be washed below the root zone. During the first few years particularly, more water should be used than is necessary to satisfy the crop needs. The excess water will bring about the deep leaching required.

Over the long haul, irrigation water and soil come into an equilibrium with one another This means that if you use poor quality water and poor irrigation practices you'll have poor soil. Water quality holds the key.

Drainage

Both surface and internal drainage must be adequate. The land must be graded well enough so that the water will not stand on the surface more than a few hours after an irrigation. Saline soils usually absorb water readily but alkali soils take water slowly, so adequate surface drainage is necessary.

Ripping the soil to a depth of 30 inches or more may be needed to shatter hardpan or other impervious layers to provide internal drainage. Water must pass through the soil to carry away the salts. Salts are not washed off the soil but are washed through the soil below the root zone.

Financing

Before any attempt is made to reclaim soil, plan to follow through to the end. This is particularly true of sodic and saline-sodic soils. Many growers who have failed did not have enough financial backing to apply enough soil amendment, or to stay financially solvent until the job was done. Unless you have adequate financing to complete the job, reclamation of salt affected soils will not be profitable.

Patience

A grower should be willing to sprinkle irrigate or flood irrigate field crops such as barley, sudangrass, irrigated pasture, or alfalfa until the land is in good production. Then and only then should he consider furrow irrigated crops or permanent crops such as trees or vines.

For at least the first year, a grower should be content to take his profits from improved land rather than from a return from his crops. A grower who will stress soil reclamation first and a cash crop later will probably reap the greatest net return over a five year period.

If you can meet these four conditions, then you can seriously consider reclaiming a saline or alkali soil.

Reclamation

Determine first if your soil is saline, alkali, or saline-alkali. An experienced agronomist who knows your area well can probably tell you offhand but even he may want to take soil samples to a laboratory for testing. Many failures may be attributed to improper diagnosis and evaluation.

Saline Soils

Reclaiming most saline soils is relatively simple if the internal drainage of the soil is good. Sufficient water must be passed through the soil to dissolve the excess salts and carry them below the root zone. The amount of water required depends mainly on the amount of salt which must be removed and how deep the soil needs to be leached. Whether a soil is sandy or fine textured has little to do with the amount of water needed, but it may have a great deal to do with the length of time needed to complete the job.

As a rule of thumb, it takes about one foot of water to remove 80 percent of salt from one foot of soil. Experience has shown that sprinkling or frequent light irrigations remove salts with somewhat less water than continuous flooding. The cost of labor and equipment to apply water at this slower rate must be considered.

Where water is in short supply or if the soils take water slowly, it may be desirable to plant a relatively salt tolerant crop such as barley after only part of the salt is removed. Irrigations to the barley crop will remove more salts and may reach a level where more salt sensitive crops may be grown.

To avoid any misconception, it cannot be emphasized too strongly that soil salinity cannot be reduced by adding soil amendments or other methods. Only copious amounts of water passing through the soil will remove excessive salts.

Alkali and Saline-Alkali Soils

Nearly all virgin alkali soils are really saline-alkali soils. For this reason they will be discussed together.

First, the land must be prepared for irrigation. This means grading the soil if it is to be surface irrigated and deep ripping if there is hardpan or other impervious layers

If the land has not previously been irrigated, temporary borders should be thrown up and the land irrigated once, twice, or more until the rate of water penetration becomes exceedingly slow. Disturbing the surface soil with a springtooth harrow or a light disc between each irrigation will also be helpful. These irrigations will remove much of the salt and reduce the amount of soil amendment that will be needed.

The excess sodium attached to the alkali soil particles must then be replaced by calcium This can be done directly by applying gypsum, a soluble salt of calcium. Calcium can also be supplied indirectly by applying an acid or an acid forming soil amendment such as sulfuric acid, sulfur or lime-sulfur.

The choice of amendment depends upon the presence of lime in the soil, the time of year it is applied, the cost of the amendment, and the speed of reclamation that the grower is willing to pay for.

Gypsum is suitable for all alkali soils and will work at any temperature above freezing. If enough finely divided gypsum is applied and mixed into the top few inches of soil, the reclamation can be completed in one or two irrigations. Gypsum is available as pit gypsum ranging from 50 to 65 percent pure, as a co-product of phosphate fertilizer plants ranging from 80 to 84 percent pure,or as a 95 to 98 percent pure product usually sold in sacks.

Acid or acid forming amendments can be used only on soils which contain lime. Fortunately nearly all alkali soils contain free lime. These amendments react with the lime to form gypsum.

Sulfur is the most common and usually least expensive of the acid forming amendments. Sulfur is slow to react because it depends upon microbial activity in moist, warm, well aerated soil. Although powder-like sulfur isn't pleasant to handle, it should be finely ground (40 mesh or smaller) so that it will rapidly convert to sulfuric acid which in turn reacts with lime to form gypsum. There is also available a dust-free form of sulfur which is equally effective and is much more agreeable to apply.

Experience has shown that the conversion of sulfur to sulfuric acid practically ceases at temperatures below 60° Fahrenheit.

Sulfuric acid is dangerous to use and should only be applied by trained people, properly equipped. It is also relatively expense. Its advantage is that it reacts with lime immediately so that only leaching is necessary to complete the reclamation.

Lime-sulfur is sold under a number of trade names. It is a dark brown liquid which contains calcium polysulfide and calcium thiosulfate. Lime-sulfur is usually applied in the irrigation water. When it is diluted with water, finely divided sulfur is released and gives the irrigation water a "milky" appearance. Once incorporated in the soil it works the same as soil sulfur but has the added advantage of being very finely divided and presumably will convert to sulfuric acid more rapidly.

Lime-sulfur should be purchased on the basis of its sulfur content. It usually contains about 24 percent sulfur and 6 to 8 percent calcium. This amount of calcium is so low that it hardly needs to be considered in alkali reclamation.

There are a few other materials which have been used for alkali reclamation. Among these are ferric sulfate, aluminum sulfate, calcium chloride, magnesium chloride, and sulfur dioxide. If you have an inexpensive source of one of these materials they can be used successfully.

The following table shows the relative values of the common soil amendments used in alkali reclamation.

Amendment	Pounds Required to Equal 1 Ton of Gypsum	Relative Value Per Ton Applied to the Soil
Gypsum (100%)	2000	1.00
Sulfur (100%)	372	5.38
Sulfuric Acid (93.2%) 66° Baume'	1223	1.64
Lime-sulfur (24% sulfur) 32° Baume'	1550	1.29

Cost of materials must be calculated on the price <u>delivered and spread</u>.

To figure the cost of pure gypsum use the following:

$$\frac{\text{Cost of gypsum applied}}{\text{Percent Purity}} \times 100 = \text{Cost of 100\% gypsum applied.}$$

For example, if you can get 82% gypsum <u>delivered</u> and <u>spread</u> for $8.50 per ton, then

$$\frac{\$8.50 \times 100}{82} = \$10.37 \text{ per ton applied}$$

To calculate how much an equivalent value of sulfur would be worth, multiply the cost of available gypsum by the relative value of sulfur:

$10.37 X 5.38 = $55.79/ton.

This is the amount you could afford to pay for sulfur and break even.

One encouraging note can be made about reclaiming alkali soils. Once reclaimed the treatments may be stopped and the alkali will not return so long as the quality of the irrigation water is good and the ground water remains deep.

Reclaiming Schedules

So much for background information. What is a suggested schedule for reclaiming a piece of saline-alkali land? Other plans may work but the following has been used successfully with a minimum of expense.

Summer Months

1. Grade the land.
2. Rip deeply (30" or deeper).
3. Disc to smooth surface and make some temporary irrigation borders.
4. Irrigate the soil at least twice or until the soil seals up.
5. Apply the equivalent of 5 tons per acre of gypsum overall -- more should be applied to the "slick spots" if they can be outlined.
6. Disc and cross disc the gypsum to mix it in the top 6 inches.
7. Irrigate again.

Fall Months

1. Work up a seedbed and apply the necessary fertilizer
2. Seed winter cereal -- preferably barley.

Winter Months

1. Irrigate during winter and early spring to keep the crop growing.

Spring and Early Summer

1. Harvest cereal.
2. Treat any bare spots in the field with another 5 tons of gypsum or equivalent per acre.
3. Disc stubble and mix in the soil amendment.
4. Irrigate and work up a flat seedbed.
5. Apply about 100 lbs/acre of actual nitrogen fertilizer.
6. Seed to sudangrass or grain sorghum.
7. Irrigate by flooding between temporary borders. Avoid furrow irrigation because this concentrates the released salts in the tops of the beds.
8. Harvest or graze the crop.

Fall Months

1. Again treat any bare or weak spots at the rate of 5 tons gypsum or equivalent per acre.
2. Disc in the soil amendment with the stubble of sudan or sorghum.
3. Irrigate.
4. Plant to irrigated pasture or alfalfa.

If sulfur or lime-sulfur is used it must be kept in mind that it is slow to react, and will not react at all when soil temperatures are below 60° Fahrenheit.

Growing alfalfa on salt affected soils has a few advantages over many other crops. It is able to utilize partially reclaimed land. Alfalfa will not tolerate alkali (sodic) soils but it can tolerate a moderate concentration of salt in the lower root zone. This means that it may be used as an intermediate crop in the reclamation process. Since alfalfa grown for forage is planted flat, the salt moves down into the soil below the root zone instead of concentrating at the tops of the plant beds. Salt will still concentrate on the levees with flood irrigation but this represents only a small portion of the total area.

In the long run, alfalfa is really not much different from other crops. The only way to grow high yields is to get rid of all surface alkali and reduce the salt content of the entire root zone to a fairly low concentration. In other words, reclaim your soil!