WATER FOR IRRIGATION

Quality

The criteria for judging the quality of water for irrigation is not the same as for domestic uses. An excellent water for household use may be of inferior quality for irrigation use; in fact, water quality criteria, from the viewpoint of soil and plant relationships, differ in most respects from the criteria for domestic or industrial water. As an example, irrigation water should contain a relatively high proportion of calcium and magnesium salts, while a high sodium ("soft water") is preferred for domestic use. Also, the concentration of boron in irrigation water is toxic to some plants at levels higher than 2 p.p.m., although these concentrations are not important for household use. One quality preferred in all water uses is a low total salt content.

Total salt content is usually expressed in terms of electrical conductivity--micromhos per centimeter ($Ec \times 10_6$)--although total dissolved solids expressed in parts per million (p.p.m.) can be used. The range of conductivity of irrigation waters in North Dakota is approximately 250-3000 micromhos per centimeter. The values correspond to a range of approximately 150-2000 p.p.m. total dissolved solids. For purposes of classification, irrigation waters are divided into four salinity groups: low salinity, C1, less than 250 micromhos/cm; medium salinity, C2, 250-750 micromhos/cm; high salinity, C3, 750-2250 micromhos/cm; and very high salinity, C4, greater than 2250 micromhos/cm. This classification is used in the diagram in Figure 1.

Soils are seldom adversely affected by saline irrigation waters provided the sodium concentration is low in relation to the concentration of calcium and magnesium. Plants on the other hand find it more difficult to obtain water from saline soil solutions. The osmotic pressure of such solutions interferes with the movement of water from the soil solution to the plant root. With this condition the plants can suffer from drought while the soil appears to have an adequate moisture supply. More often the plants will show no outward signs of salinity other than reduced yields. Varying tolerance to salinity is exhibited by different plants. Crops that can be grown in North Dakota that have a low salinity tolerance include: strawberry, plum, apple, beans and most clovers. Medium tolerance is exhibited by most garden crops, corn, wheat, oats, rye and alfalfa. A high tolerance is shown by barley and sugar beets.

The relationship of the amount of sodium to the calcium and magnesium is the second most important factor in determining irrigation water quality. The term used to define this relationship is called the sodium adsorption ratio (SAR) which is calculated by this equation:

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

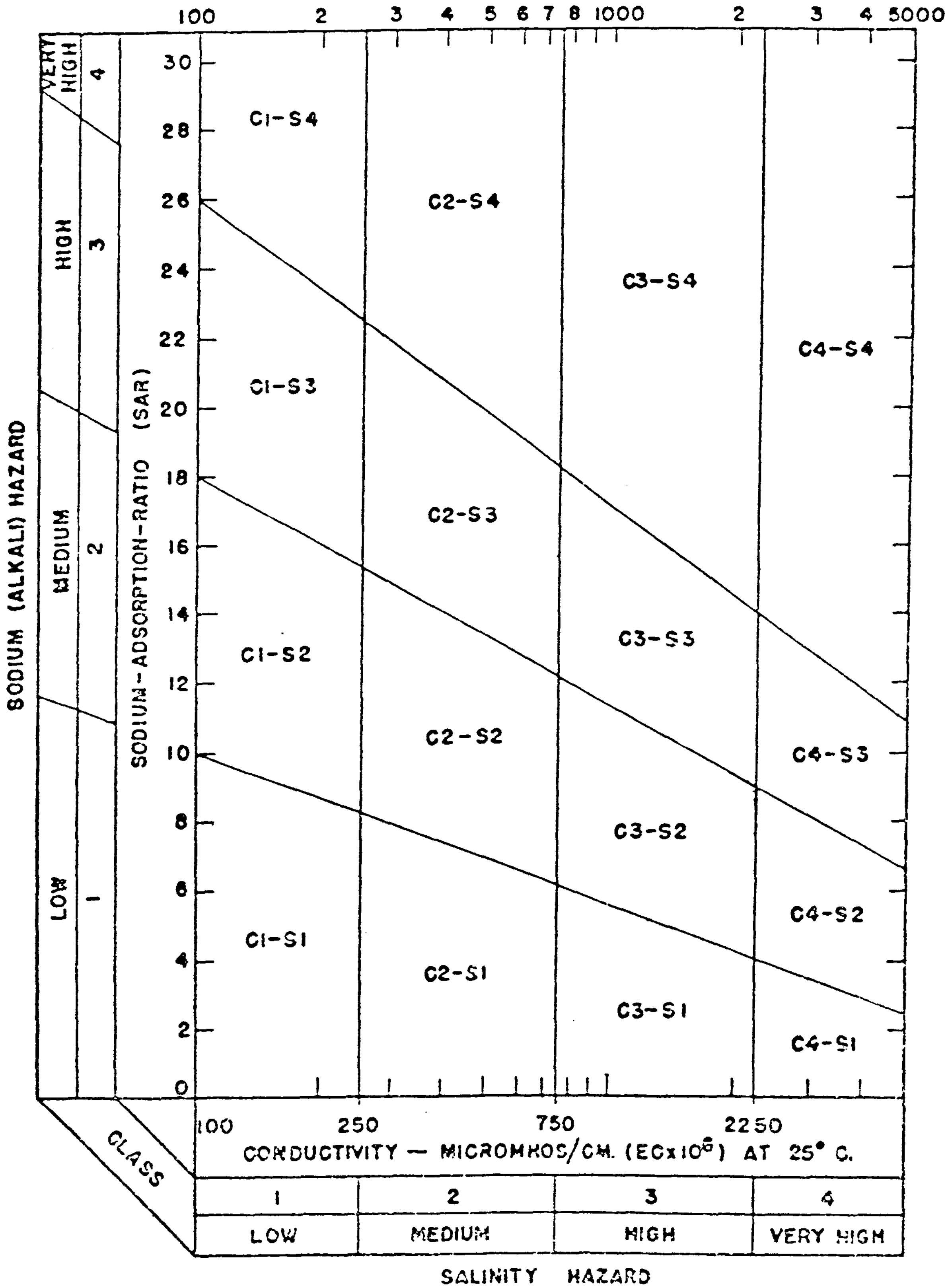


Figure 4.1 - Diagram for the Classification of Irrigation Water

Guide to Water Quality Standards
for North Dakota Irrigation Waters
4/1/82

Assumptions

- That the soils are well drained
- No aquolls unless drainage is economically feasible
- No matriborolls or very slowly permeable strata
- Water SAR greater than 25 is not suitable

Rating	Max SAR	Maximum Salinity (micromhos)	Soils Texture	Management for Salinity Control	Crop
C1S1	Less than 6	750	All	No	All
C2S1	6 to 8	750	All	Clays	All
C2S2	8 to 12	750	Loam or coarser	No	All
C2S3	12 to 15	750	Sandy loams or loamy sands	No	All
C3S1	Less than 6	2250	Clay loam or coarser	Some	All but salt sensitive
C3S2	6 to 9	2250	Fine sandy loam or coarser	Some	All but salt sensitive
C3S3	9 to 12	2250	Sandy loam or coarser loamy sands	Some	All but salt sensitive
C3S4	12 to 15	2250	Sandy loam or coarser loamy sands	Some	All but salt sensitive
C4S1	Less than 4	3000	Fine sandy loams or coarser	Leaching program	Salt tolerant
C4S2	4 to 8	3000	Sandy loam or loamy sands	Leaching program	Salt tolerant
C4S3	8 to 12	3000	Loamy sands	Leaching program	Salt tolerant
C4S4	Greater than 12	3000	None		

Figure 4.2

There is a significant relationship between the SAR of an irrigation water and the exchangeable sodium percentage of the soil irrigated with that water. It is possible, by knowing the SAR, to anticipate the effect of the water on the soil. Irrigation waters with an SAR of less than 8 will have little effect. Values to 15 are marginal and continued use of water with an SAR greater than 20 will lead to serious sodium problems.

Both soils and plants are adversely affected by high sodium irrigation water. Sodium affected soils are relatively impermeable to water. They are hard when dry and sticky when wet, which causes difficulty in tillage. The adverse physical conditions retard or prevent germination and are generally unfavorable for plant growth. In addition, the sodium ion is toxic to many plants.

The collection of a calcium carbonate scale in water lines, boilers and water heaters is familiar to all. The same reaction can take place when irrigation water containing a high amount of bicarbonate is applied to the soil. As calcium carbonate precipitates, the ratio of sodium to calcium increases with a corresponding increase in the SAR value. Bicarbonate water, therefore, presents a special type of sodium problem that can occur in North Dakota.

Updated guidelines for interpretation of water quality for irrigation take into account not only salinity but also a modification of the sodium adsorption ratio (SAR) value. As stated previously if excessive quantities of soluble salts occur in the root zone, the crop has difficulty extracting water from the soil resulting in slow or reduced growth. Also low salt content water can result in poor soil permeability due to the capacity of pure water to dissolve and remove calcium and other soluble salts in the soil. The modification of the SAR value takes into account not only the sodium content relative to calcium and magnesium but also the bicarbonate and carbonate content: it is named the adjusted SAR and is a calculated figure. Therefore, a simultaneous analysis of the adjusted SAR and the total salt concentration of the water are applied in estimating the salinity and permeability hazard of irrigation waters to soils.

Boron is an element that is essential to plant growth in small quantities, but if this concentration is exceeded by only a small amount, it becomes toxic to plants. Most waters contain some boron and all irrigation water must be checked for toxic concentrations. Nearly all crops grown in North Dakota are at least semitolerant to boron and can endure permissible limits of 2.0 p.p.m. Alfalfa and sugar beets, among others, are more tolerant and can endure concentrations up to 4.0 p.p.m. Boron found in irrigation water has no effect on the soils, but produces injury to plants irrigated with it.

Water is classified as to its suitability for irrigation on a specific soil. A chemical analysis of the water, the physical and chemical properties of the soil and certain assumptions regarding the conditions under which the water will be used are made. Some factors that determine the suitability or success of an irrigation project are the internal drainability of the soil, leaching, choice of crops and control practices. Figure 4.2 is the standard used in North Dakota for irrigation recommendations. The maximum allowable salinity and alkalinity are listed for each irrigation soil group.

Salt is added to the soil with each irrigation. If drainage is impaired, a water table may develop and salts can accumulate in the root zone.

Adequate drainage is essential to both control the water table and permit leaching water to be removed from the root zone. Plants take water but very little salt from the soil. Salts left in the root zone after irrigation must be moved below the root zone or carried away by drains through the addition of water in excess of the soil capacity. This leaching can be accomplished by adding extra irrigation water or relying on natural rainfall during noncropping periods.

Quantity

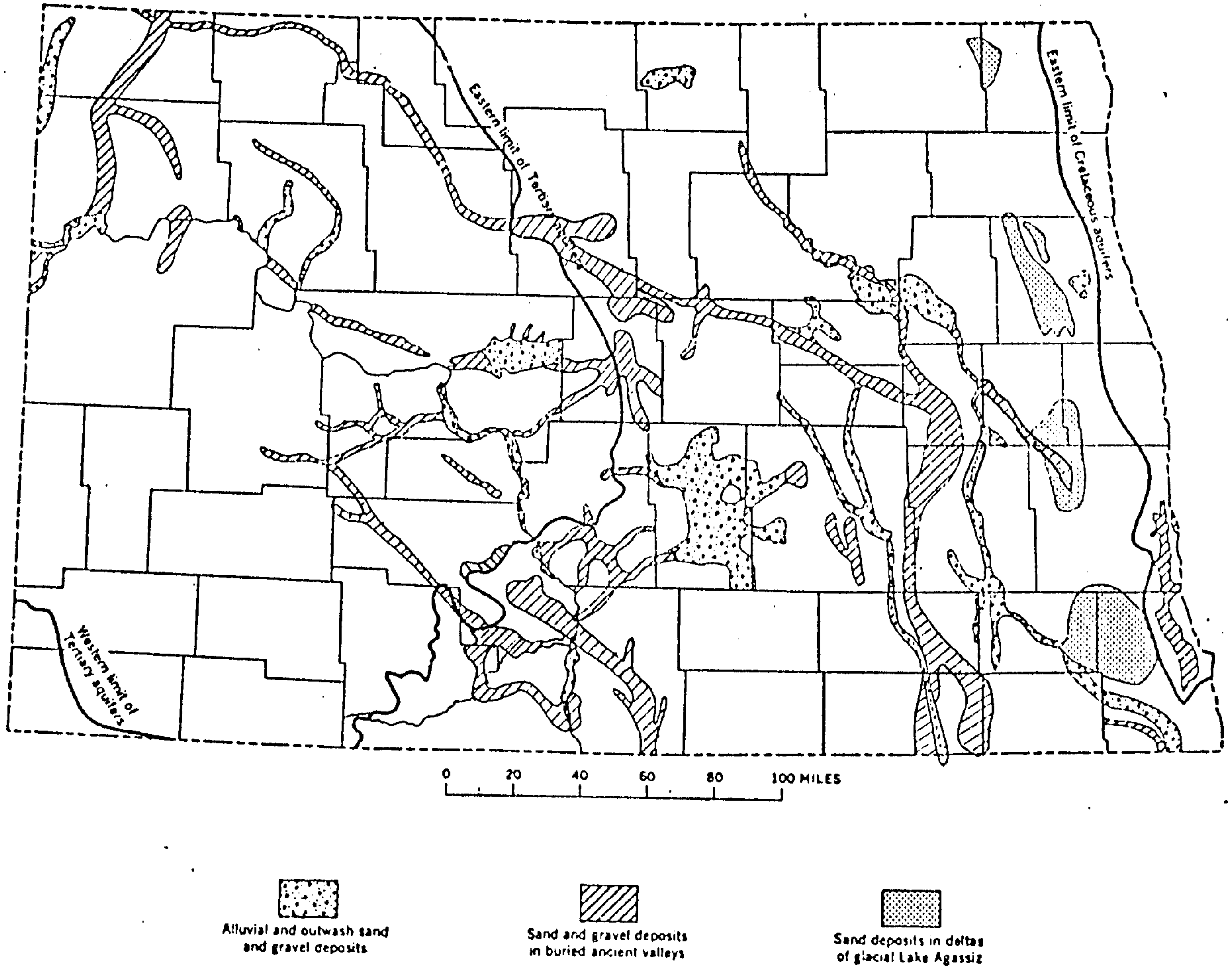
The quantity of water required for a reliable irrigation system depends on the location, crops grown, soil type and the method and type of irrigation used. The main requirement would be a water supply that would meet the crop needs during the period of highest moisture use without depleting soil moisture below 50 percent of the amount available.

Crops vary in their water requirements, both seasonal and at periods of peak use. These requirements can be calculated for a particular crop and location using the method described in Chapter 3, Consumptive Use.

In judging the adequacy of a water source for irrigation, consideration must be made for seasonal and peak use quantities. A seasonal supply should be between 18 and 24 inches for each acre to be irrigated. This supply should be available throughout the growing season. The withdrawal rate should be at least 6 gallons per minute for each acre irrigated.

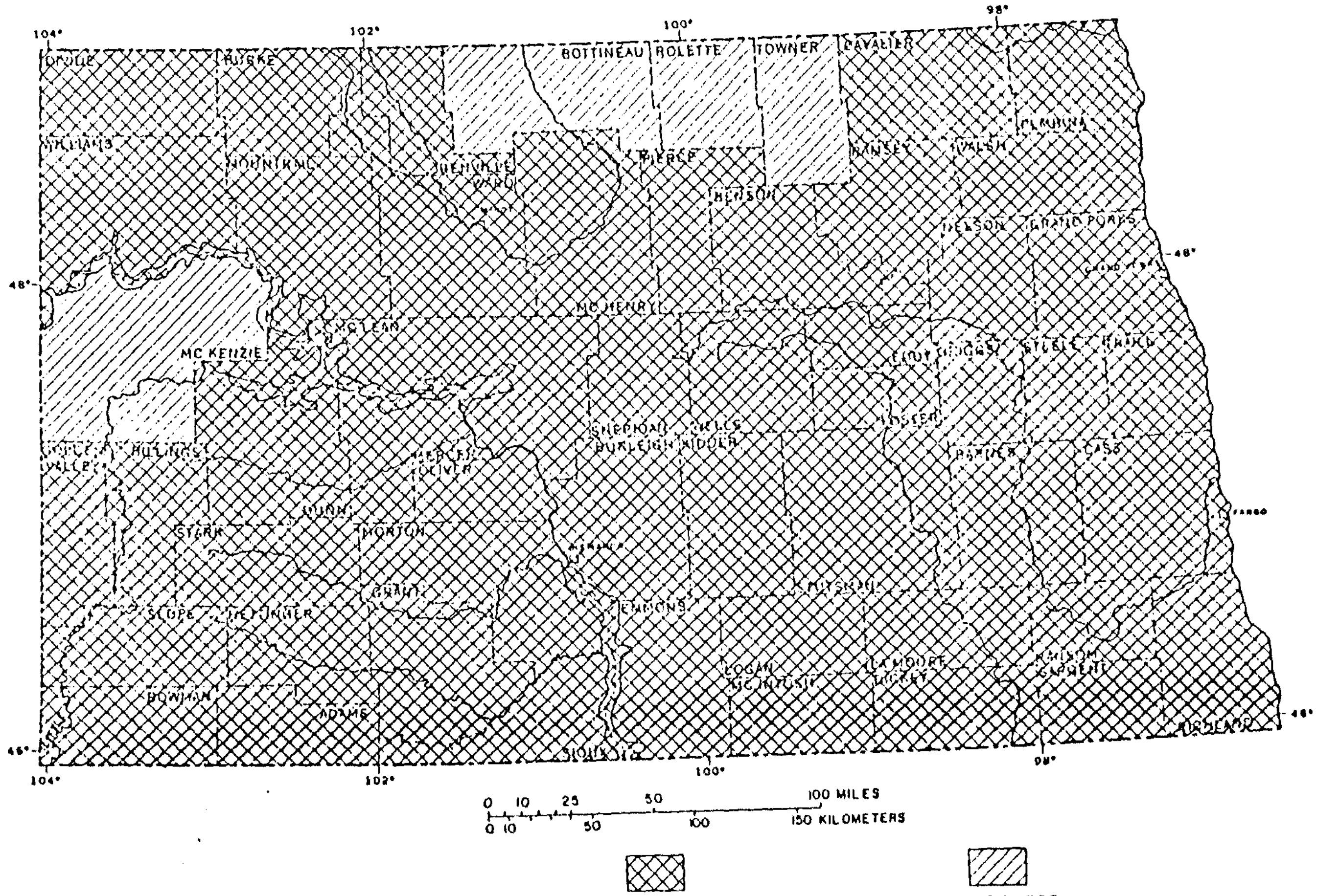
Surface water supply for irrigation in North Dakota is limited to the major flowing streams that have an adequate flow during July and August or the use of storage dams to hold spring runoff for summer use. When storing water for irrigation, capacity must be added for seepage and evaporation losses in the reservoir.

Ground water sources for irrigation in North Dakota are found in buried preglacial river channels and glacial outwash and diversion channels. The map in Figure 4.3 shows the location, extent and type of the major aquifers in the state. These sources can produce water of sufficient quantity and irrigation quality. Water from other aquifers are usually limited in quantity and contain excessive dissolved salts. Detailed investigative drilling is required prior to using ground water sources. County ground water studies can be used as a general reference for locating a water supply for irrigation. Figure 4.4 shows the progress being made on county surveys.



LOCATION OF MAJOR AQUIFERS

Figure 4.3



County ground-water studies in North Dakota.

Figure 4.4