# Irrigation Certification In Saskatchewan

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## Contents



## Context

The purpose of this document is to provide transparency on the methodologies used by the Ministry of Agriculture's Crops and Irrigation Branch to assess agricultural land and water supplies for irrigation suitability. The assessments for irrigation suitability and data collection are completed by the branch with the exception of unique cases where large blocks of land are contracted out to private industry. Soil data and field observations will also be accepted from private industry if the submission requirements detailed in Appendix A are met.

## Introduction

*The Irrigation Act, 2019*, administered by the Ministry of Agriculture, requires all individuals wishing to develop new irrigation projects in Saskatchewan to first obtain an Irrigation Certificate. Land is certified for irrigation development under the criteria that it will be permanently productive under an irrigated cropping system and that no damage to neighbouring lands will occur.

The Irrigation Certificate demonstrates that the ministry strives for environmental sustainability of irrigation projects. Certification protects the province's water and related land resources, as well as protecting the irrigator's significant investment in irrigation and related cropping equipment.

To effectively evaluate the suitability of a parcel of land, one must be able to predict what physical, chemical and biological changes may occur to the soil with irrigation. Developing lands not suitable for irrigation can lead to degradation of soil quality and reduced crop yields. For example, irrigating lands which have inadequate drainage can lead to increased water-logging and salinization.

Ideal land for irrigation development generally consists of medium textured, well-drained, non-saline soils that have sufficient moisture holding capacities. The spatial extent of ideal, Class 1A irrigation land is very limited as most land in Saskatchewan will have some degree of soil and/or landscape limitation that will affect its suitability for irrigation. Therefore, an in depth soil and landscape assessment, with a particular focus on salinity and groundwater, is required on all lands prior to irrigation development to ensure that they are suitable for irrigation.

## Irrigation Certification Standards

The guidelines for classifying land for irrigation in Saskatchewan are defined in the document entitled *An Irrigation Suitability Classification System for the Canadian Prairies (ISCS), 1987.* The ISCS describes the soil and landscape properties, along with the associated classes and ranges, which are considered when assessing the suitability of a parcel of land for irrigation development (Appendix B).

The ISCS is used to interpret the suitability of land for irrigation by utilizing existing soil and landscape data that is available in the provinces soil survey reports. Due to the limited detail and scale of information found in the soil survey reports, a more detailed, in-field investigation is necessary when assessing individual parcels of land. Most parcels of land consist of multiple soil survey polygons that are each assigned an irrigation rating of excellent, good, fair, or poor, by utilizing the ISCS criteria along with information from the in-field soil investigation. This document outlines the methodology used to assign an irrigation recommendation to a parcel of land.

## Land Rating

In Saskatchewan, land is generally assessed for irrigation suitability on a quarter section basis. Quarter sections are either deemed to be irrigable (I), non-irrigable (N), or partially irrigable (Ip). An irrigable rating indicates that the land is suitable for a full quarter section pivot of approximately 130 acres. In some instances, the irrigable rating may be dependent upon a drainage requirement (Id).

A parcel of land will not receive an Irrigation Certificate if greater than **15 per cent of the proposed irrigated area is considered to be non-irrigable** due to any class 4D severe limitation as outlined in the ISCS. A severe limitation is often an area with severe soil salinity and/or has a high risk of water logging or ponding under irrigated conditions.

Further, a parcel of land will not be certified for irrigation if greater than **30 per cent (±10%) of the proposed development area is found to be impacted by moderate to severe levels of salinity in the bulk of the soil rooting zone**. Although moderately saline areas are by definition only a moderate limitation they can be downgraded to a severe limitation if the moderately saline areas are expected to expand or intensify with irrigation. However, if the salinity status of the land is predicted to improve as a response to irrigation, a higher percentage of area impacted by moderate salinity may be tolerable.

## Salinity

Soil salinity is influenced by the flow patterns of both surface water and groundwater. Generally, the salinity status of a soil is a reflection of the long-term hydro-geologic equilibrium of these flow patterns.

Soil salinity is caused by evaporative salt concentration and is generally found in areas affected by a shallow water table within 1.2 to two metres from the soil surface depending on the soil texture. The presence of a shallow water table can occur in ground water discharge areas, where there is a low hydraulic conductivity barrier within two metres of the soil surface, or around landscape depressions that are prone to ponding, such as sloughs. It is generally accepted that groundwater discharge areas will not respond well to irrigation. Adding water to these areas will have the potential to lead to further water-logging and increased salinization.

Moderate to severe-saline areas that are predicted to be adversely impacted by irrigation should be assigned a class 4D severe limitation. Inverted salinity profiles, with higher concentrations of salt at the soil surface relative to at depth, indicate a high water table and poor internal drainage. Soluble salt concentrations of greater than 6 dS $m^{-1}$ in the surface 30 cm provide an indication of the occurrence of significant groundwater discharge.

A barrier layer with a low hydraulic conductivity encountered within two metres of the soil surface creates a significant potential for increased salinization with irrigation development. This may include any textural or geological discontinuity, including a clay layer that is overlain by a more coarsely textured soil or a solonetzic Bnt, both of which may lead to the formation of a perched water table following irrigation development.

In some scenarios, provided sufficient internal drainage exists, soil salinity levels may decrease as a response to irrigation. A downward salt profile with higher levels of salinity in the sub-soil can be an indication of a net downward movement of water and salts. A water table that is consistently below two metres is optimal for leaching salts downwards in the soil profile. Also, surface water induced salinity, generally found around the edges of "recharge" sloughs, may respond well to irrigation if surface drainage improvements are implemented.

Although some lands impacted by salinity can respond well to irrigation, these fields will likely require a higher level of soil and water management that focuses on preventing water table rise and waterlogging in low-lying areas.

The following management practices can help reduce excess water in low-lying areas:

1) Irrigating below field capacity to reserve soil water storage for potential precipitation events.
2) Installing a variable rate irrigation system that allows water to be throttled-back or turned off in chosen areas.
3) Programing the pivot to speed up over low-lying areas if they become saturated.
4) Establishing a deep-rooted high water use crop such as alfalfa in the low-lying areas to help reduce excessive moisture.

Annual fall leaching applications will help to maintain the salts at depth in the soil profile. Consideration may have to be given to growing salt tolerant crops in areas that have moderate levels of salinity (> 4 dS/m) in the surface soils. Further, yield potential may be reduced in some of these areas relative to the non-saline parts of the field. Also, in some instances sub-surface drainage improvements may be beneficial to alleviate salinity stresses.

## Sloughs and Surface Drainage Improvements

Temporary sloughs that drain in the spring and can be cultivated are generally considered to be a moderate limitation. Sloughs of this nature may not always require drainage improvements prior to irrigation development. However, if these sloughs become problematic upon irrigation development surface drainage improvements may have to be considered.

Ephemeral sloughs that are classified as being seasonal or semi-permanent are considered to be a 4D severe limitation and will count towards the non-irrigable portion of the parcel. Implementing drainage improvements to remove excess surface waters can be used to upgrade these areas to irrigable provided the sloughs are non-saline.

Sub-surface (tile) drainage improvements may be beneficial to alleviate salinity stresses in low-lying areas that are prone to waterlogging. It is not typically feasible to install tile drainage over large areas of land but it can be a valuable management strategy to target specific problem areas in a field. Consideration should not be given to implementing any drainage improvements to these areas without first conducting an in-depth hydro-geologic investigation of the area. Managing irrigation on saline soils with tile drainage requires fall irrigation after harvest to help promote downward movement of water and leaching of salts out of the soil rooting zone. Soil salinity can return if irrigation management is neglected.

Semi-permanent to permanent sloughs that are influenced by ground-water discharge will be classified as a 4D severe limitation. It is not feasible to remediate ground-water discharge areas with surface and/or subsurface drainage improvements.

## Assessment Protocol

Assessing land for Irrigation Certification in Saskatchewan consists of a background review of all pertinent information as well as a detailed in field soil investigation.

A background review consists of compiling existing soil survey data, rural land assessment data and aerial imagery. A thorough review of existing data is performed to determine if a field investigation is warranted. In some cases, land can be dismissed prior to the field investigation if it appears that it will have little potential for becoming certified. Also, prior to any field investigations, land owners are notified and a call is made to Sask 1st Call to locate any potential buried utility lines.

Aerial imagery, as available through FlySask, Google Earth and other sources, can be useful for identifying potential saline or problem areas prior to the field investigation. Air photos are also useful for identifying areas which may require drainage improvements in the future.

## Field Investigation

Field investigations consist of detailed soil salinity surveys utilizing an automated dual dipole EM38 geo-referenced with RTK survey grade GPS equipment. Depending on the variability of the soil, surveys will typically be carried out on a 50 to 70 m transects. Extra readings will be collected from irregular areas where salinity is suspected. Also, in order to improve the accuracy of the topography maps, surveyors are encouraged to collect readings from slough bottoms/depressional areas and from knolls and ridge tops. Accurate topography maps help with the interpretation of the processes that may be influencing water movement and salinization within the landscape.

Soil samples are collected in the field from a minimum of four sample points from a 160acre land unit or 12 samples points from a 640 acre land unit provided there is a uniform soil type. Fields that have been identified as being solonetzic in soil survey reports may require a higher intensity of soil samples to more accurately determine the extent of area impacted by sodicity.

| Texture | % Field Capacity | % Wilting Point | % Available Moisture Holding Capacity | Available Moisture inches/foot | Infiltration Rate mm/hr | in/hr |
|---|---|---|---|---|---|---|
| Loamy Sand (LS) | 10 | 5 | 5 | 0.84 | 25 | 1.00 |
| Sandy Loam (SL) | 18 | 8 | 10 | 1.68 | 18 | 0.70 |
| Fine Sandy Loam (FL) | 20 | 9 | 11 | 1.85 | 15 | 0.60 |
| Very Fine Sandy Loam (VL) | 22 | 10 | 12 | 2.02 | 13 | 0.50 |
| Silt Loam (SiL) | 22 | 10 | 12 | 2.02 | 9 | 0.35 |
| Loam (L) | 24 | 12 | 12 | 2.01 | 8 | 0.30 |
| Clay Loam (CL) | 26 | 13 | 13 | 2.23 | 6 | 0.25 |
| Clay (C) | 40 | 22 | 18 | 3.02 | 4 | 0.15 |

**Table 3.** Estimated infiltration rates and moisture holding capacities of different soil textures based on the field tests of O.P. Bristol in dark brown soils.

Sample locations are strategically identified by the surveyor with the objective of covering the range of EM38 readings found in the field. Soil cores are taken to a depth of 1.2 m in 30 cm increments. Fields that are suspected to be influenced by high water tables should have a minimum of one core drilled to two m in the affected area. As the soil samples are collected notes are taken on horizon sequence, colour, presence of salts, soil structure, evidence of gleying or mottling, moisture status (dry, slightly moist, moist, saturated) and parent material.

Soil textures are determined by hand and samples are sent to the lab for detailed saturated paste extraction soil salinity analysis. Soil infiltration rates and moisture holding capacities are estimated based on soil textures (Table 3).

## Data Interpretation

A weighting method is used to develop a regression equation to convert apparent electrical conductivity (ECa) values obtained with the EM38 to saturated paste electrical conductivity (ECe) values determined in the lab (Table 4). An $R^2$ value >0.75 for the regression equation indicates that there is a strong relationship between the soils ECa and ECe. If the $R^2$ value is <0.75 then it may be necessary to take additional steps for proper interpretation of the ECa data. The pedologist may remove outliers from the regression equation if this can be justified and improves that accuracy of the salinity maps. In some cases, additional soil samples will need to be collected.

| Depth (m) | Horizontal | Vertical |
|---|---|---|
| 0.0 – 0.3 | 0.54 | 0.22 |
| 0.3 – 0.6 | 0.26 | 0.35 |
| 0.6 – 0.9 | 0.13 | 0.25 |
| 0.9 – 1.2 | 0.08 | 0.18 |

**Table 4.** Weighting factor of contribution of each soil sample depth increment for converting soil EC values to EM38 readings (adapted from Wollenhaupt et al. 1986).

Field data is processed using a Geographic Information System (GIS) program, such as ArcGIS and detailed salinity and topography maps are generated at a scale 1:5000. A salinity map is generated for the horizontal EM38 orientation (0-75 cm) and the vertical EM38 orientation (0-150 cm). The salinity classes used to generate these maps are the same as those in the ISCS. The total area of each salinity class is calculated for both the horizontal and vertical EM38 map.

It is important to reference the soil analytical results when interpreting the soil salinity maps particularly when determining the soil salinity status of the top 0-75 cm. When interpreting the 0-75 cm salinity map, the soil analytical data can help identify if the soil salinity is evenly distributed in that layer, concentrated at the bottom, or concentrated at the soil surface.

## Report Generation

A report is prepared which summarizes the findings of the investigation and makes a recommendation regarding the irrigation suitability of the land (Appendix B). Salinity maps, topography maps, soil survey data and aerial imagery should all be utilized for interpreting soil processes and ultimately predicting the response of the land to irrigation.

The irrigation suitability report will include a description of the soil associations, soil textures (0-60 cm), infiltration rates and ISCS irrigation ratings for the parcel. The report also includes the two salinity maps (horizontal and vertical orientation), the topography map, soil analytical data, the regression analysis, along with any other pertinent material. Any potential limitations to irrigation development and/or precautions should be summarized. This may include any soil salinity, sodicity, drainage or any other issues encountered.

Recommendations should be made with regards to water and cropping management for any land that is considered suitable for irrigation development. Water management recommendations should be made which consider the potential for run-off, leaching and water table build-up, surface crusting and/ or movement of salts. Cropping recommendations may need to be made for the growth of salt tolerant crops and/or the growth of high water use crops to lower water table in potentially affected areas.

Drainage recommendations or requirements should be made for all lands that are found to have imperfect drainage.

*Drainage Recommendation*- A recommendation for drainage improvements should be made if water ponding and/or logging is expected with irrigation development. Land that has a recommendation for drainage can be developed prior to implementing the drainage improvement.

*Drainage Requirement*- Drainage will be required if it is expected that:

1. There will be any adverse off-site impacts;
2. Any increased salinization as a response to irrigation; or
3. The total area impacted by severe limitations exceeds 15 per cent. For land with drainage requirements the drainage improvements must be completed prior to development.

## Appendix A: Submitting Soil Surveys for Irrigation Certification

The following guidelines are in place to ensure that data being submitting is accurate and consistent for the Government of Saskatchewan Crops and Irrigation Branch irrigation suitability assessment process.

1. Proponents must submit an Irrigation Development Application form (formerly a Request for Technical Assistance form) and pay any associated fees paid prior to the submission of soil survey data. All irrigation projects must follow the irrigation development process to ensure all regulations are met.
2. Only EM38 data will be accepted.
3. The pass distance between EM38 transects is 50 to 70 metres.
4. Raw data needs to be submitted as .csv or .txt file and should include the following columns: horizontal EM readings, vertical EM readings, X/Northing coordinate, Y/Easting coordinate and Z/Elevations, along with **units** for each reading. Spatial data needs to be submitted in the WGS 1984 UTM coordinate system. A shape file optionally be included along with the .csv or .txt.
5. A minimum of four soil sampling locations per 160 acres are required. Soil samples must be taken from surface at 30 cm increments to a 1.2 m depth. Each 30 cm increment is to be analyzed separately.
6. Soil samples must include the horizontal and vertical EM38 reading, at that exact location, on the same day that the survey was conducted. This cannot be an interpolated number.
7. **Soil sampling analysis will only be accepted if the saturated paste method was used.** 1:1 or other soil extraction methods do not produce consistent results for soil salinity analysis across different soil types. Soil samples need to be analyzed for:

    a. Conductivity uS/m (**saturated paste extraction**)
    b. pH
    c. SAR (sodium adsorption ratio)
    d. Per cent Saturation
    e. Calcium mg/L (**saturated paste extraction**)
    f. Potassium mg/L (**saturated paste extraction**)
    g. Magnesium mg/L (**saturated paste extraction**)
    h. Sodium mg/L (**saturated paste extraction**)
    i. Sulfur (as $SO_4$) mg/L (**saturated paste extraction**)
    j. Chloride mg/L (**saturated paste extraction**)
    k. Texture (hand or hydrometer)

8. Soil analysis needs to be submitted as the unedited report from the lab.
9. Field notes should include soil temperature (multiple times if temperatures vary during the EM38 survey), **soil moisture conditions at each 30 cm to a 1.2 m depth**, a visual

description of the soil cores, any areas of poor growth, water logging, ponding, saline tolerant vegetation and or any other anomalies found in the field. Also include a minimum of one photo of the field, on the day of the survey that is labeled with the land location.

10. Once the application form, fees and data have been submitted, the Crops and Irrigation Branch will generate the soils maps, write the Agro Environmental Report and issue an Irrigation Certificate if applicable.

## Appendix B: Irrigation Rating Tables from "An Irrigation Suitability Classification System for The Canadian Prairies"

**Table 1.** Soil features affecting irrigation suitability (ISCS, 1987).

| Soil Feature | Degree of Limitation: 1 None | 2 Slight | 3 Moderate | 4 Severe |
|---|---|---|---|---|
| d Structure | Granular<br>Single Grained<br>Prismatic<br>Blocky<br>Subangular Blocky | Columnar<br>Platy | Massive | |
| k Ksat (mm/hr) (0-1.2m) | >50 | 50 - 15 | 15 - 1.5 | <1.5 |
| x Drainability (1.2-3m) (mm/hr) | >15 | 5 - 15 | .5 - 5 | <.5 |
| m AWHC mm/1.2m (% vol.) | | | | |
| subhumid | >120 (>10) | 120 - 100 (8 - 10) | 100 - 75 (6 - 8) | <75 (<6) |
| subarid | >150 (>12) | 120 - 150 (12 - 10) | 100 - 120 (10 - 8) | <100 |
| q Infiltration Rate (mm/hr) | >15 | 1.5 - 15 | | <1.5 |
| s Salinity (dS/m) (m) | | | | |
| 0 - 0.6 | <2 | 2 - 4 | 4 - 8 | >8 |
| 0.6 - 1.2 | <4 | 4 - 8 | 8 - 16 | >16 |
| 1.2 - 3 | <8 | 8 - 16 | >16 | >16 |
| n Sodicity (SAR) (m) | | | | |
| 0 - 1.2 | <6 | 6 - 9 | 9 - 12 | >12 |
| 1.2 - 3 | <6 | 6 - 9 | 9 - 12 | >12 |
| g Geological Uniformity 0 - 1.2m | 1 Textural Group | 2 Text. Groups, Coarser Below | 2 Text. Groups, Finer Below<br>3 Text Groups, Coarser Below | 3 Text Groups, Finer Below |
| 1.3 - 3m | 2 Text. Groups | 3 Text. Groups, Coarser Below | 3 Text Groups, Finer Below | |
| h Depth to Water Table (m) | >2 | 2 - 1.2 (if salinity is problem) | | <1.2 |
| w Drainage Class | Well,<br>Moderately Well,<br>Rapid | Imperfect | | Poor,<br>Very Poor |

**Table 1.** Continued

| Soil Feature | Degree of Limitation: 1 None | 2 Slight | 3 Moderate | 4 Severe |
|---|---|---|---|---|
| * Texture (Classes) | L, SiL, VFSL, FSL | CL, SiCL, SCL, SL | C, SC, SiC, LS | HvC<br>Gr, CoS, LCoS, S |
| - - - - - - - - - | - - - - - - - | - - - - - - - | - - - - | - - - - |
| (Groups) | Medium | Moderately Fine<br>Moderately Coarse | Fine<br>Coarse | Very Fine<br>Very Coarse |
| * Organic Matter % | > 2 | 1 - 2 | | < 1 |
| * Surface Crusting Potential | Slight | Low | | Moderate |
| * No symbol proposed for these factors since they will not be identified as subclass limitations. | | | | |

**Table 2.** Landscape features affecting irrigation suitability (ISC, 1987).

| Landscape Features | Degree of Limitation: A None | B Slight | C Moderate | D Severe |
|---|---|---|---|---|
| t1 Slope (%) (Simple) | <2 | 2 - 10 | 10 - 20 | >20 |
| t2 (%) (Complex) | - | <5 | 5 - 15 | >15 |
| e Average Local Relief (m) | <1 | 1 - 3 | 3 - 5 | >5 |
| p Stoniness Classes (% Cover) | 0, 1, & 2 | 3 | 4 | 5 |
| i Inundation (Freq.) Flooding | 1:10 (yr) | 1:5 (yr) | 1:1 (annual - spring) | 1:<1 (seasonal) |
| c* Potential Impact on Non-Target (Non-Irrigated) Areas | None | Low | Medium | High |
| a* Potential for Adverse Impact on Irrigated Areas | None | Low | Medium | High |
| v* Horizontal Variation of Infiltration | Very Low | Low | Medium | High |

## Appendix C: Water Quality

Irrigation water sources in Saskatchewan involve surface water, such as rivers, sloughs, and lakes, or groundwater. Water quality varies from source to source. Stagnant water bodies which are not flushed by a runoff event and low flowing streams fed by groundwater, have a greater chance of being of poor quality. Each source should be sampled and analyzed to ensure it is compatible with the land to be irrigated.

Factors affecting water quality are the concentration and type of salts. These factors are expressed as EC, in milliSiemens per centimeter (mS/cm), or as total dissolved solids (TDS), in milligrams per litre (mg/l). Generally, 1 mS/cm of EC is equivalent to 640 mg/l of TDS, but can be as high as 1,000 mg/l. All waters add salt to the soil. Waters with high ECs will salinize the soil and require irrigation beyond crop demand. The leaching of salts by better quality waters usually occurs during spring runoff or post-growing season irrigation/precipitation.

The two parameters of greatest importance are EC and Sodium Adsorption Ratio (SAR). Irrigation with waters high in sodium results in the breakdown or dispersion of the soil structure. This leads to surface sealing and crusting conditions which can inhibit crop establishment. The permeability of the soil may also be reduced, resulting in runoff. Figure 1 is the guideline used in Saskatchewan, based on in-province research, to determine the suitability of the water for irrigation. Although the water may be compatible with the soil for irrigation, the producer must also ensure crop selections (i.e. salt tolerances) match water quality.

In general, the quality of major water courses in Saskatchewan is usually suitable for irrigation. Rivers and lakes which have their headwaters in the mountains are of the best quality. Rivers and creeks not having the benefit of mountain origin are generally of poorer quality, due to salt loading from the lands over which they pass.

Irrigators need to be aware of the quality of their water source and any fluctuations, seasonal or otherwise, that occur. This is especially true when growing any crops whose yield is particularly sensitive to salt, such as vegetables, fruits and trees.

Other elements may have to be considered in the assessment of irrigation water quality. **Boron**, found largely in groundwater, can limit water's suitability when concentrations exceed 0.5 mg/l.

The presence of **bicarbonate** can cause precipitation of calcium and magnesium carbonates, which can increase the sodium hazard and decrease the soil's permeability.

Other ions, such as **chloride** and **sodium**, can harm certain plants if found in higher concentrations. The latter two ions are not problems typically encountered in Saskatchewan water supplies.

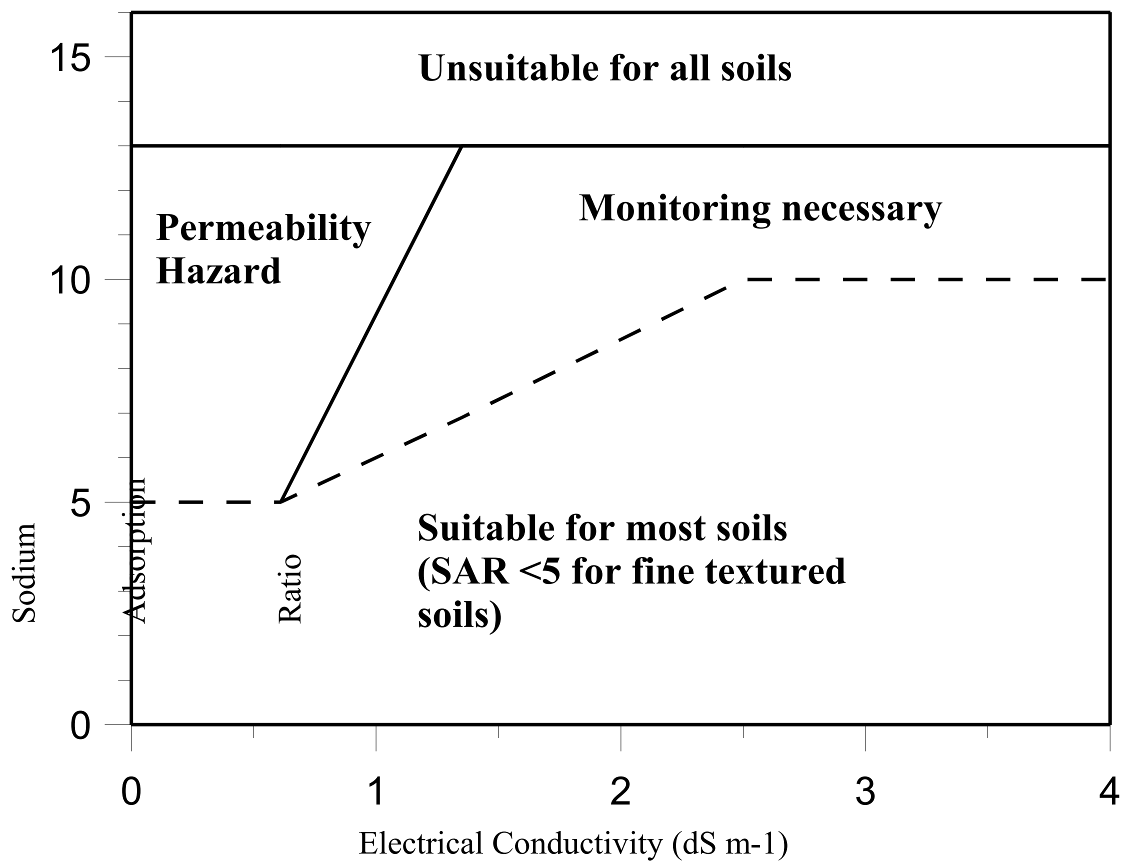


**Figure 1:** Recommended guidelines for use of sodic waters in irrigation applicable to 95 per cent of the soils in Saskatchewan (Steppuhn and Curtin, 1993).