Salinity Mapping for Resource Management

within the Blood Indian Reserve, Alberta

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March 1997

Canada

Agriculture - Building a Healthy Environment

Alberta

Abstract

This report presents a methodology to map salinity at a municipal scale and applies this procedure to the Blood Indian Reserve in southern Alberta. The methodology was developed for the County of Vulcan (Kwiatkowski et al. 1994) and is being applied to other Alberta municipalities which have identified soil salinity as a concern.

Soil salinity is a major land degradation issue in the Blood Indian Reserve. The information on salinity location, extent, type and control measures presented in this report will help the Reserve to target salinity control and resource management programs.

The methodology has five steps:

1. The location and extent of saline areas are mapped based on existing information including aerial photographs, maps, satellite imagery, and information from local personnel and field inspections.
2. Saline areas are classified on the basis of the mechanism causing salinity. The mechanism is important because it determines which control measures are appropriate. Eight salinity types are recognized within Alberta but only seven types are found on the Blood Indian Reserve. These are: contact/slope change salinity, outcrop salinity, depression bottom salinity, coulee bottom salinity, irrigation canal seepage salinity, slough ring salinity and artesian salinity.
3. Cost-effective, practical control measures are identified for each salinity type.
4. A digital data base is created in ArcInfo format with geographically referenced information on salinity location, type and extent. This data base can be easily managed and transformed into ArcView format. It can be used to create maps and calculate statistics. Additional text and graphic information can be added to the data base as the data become available.
5. Using the digital data base, a colour-coded 1:100 000 map of the Reserve is prepared, showing salinity location, extent and type. A report summarizing the information is also prepared.

Analysis of the mapping data shows that 384 saline areas occur on the Reserve and occupy a total of 1 833 ha (4 529 ac). This represents 1.3% of the Reserve's total area. Only saline areas visible on the soil surface are mapped. This provides information needed by the Reserve to target sites for further investigation. The lands surrounding visible saline seeps may have saline subsoils, resulting in a greater salinity risk. The salts in the subsoil can rise up into the root zone if weather conditions or cropping practices change. Thus, salinity control practices may benefit crop yields over a much broader area than just the visible seep.

Contact/slope change salinity is the dominant salinity type (occupying 46.5% of all saline land on the Reserve), followed by outcrop salinity (32.5% of saline land) and depression bottom salinity (14.6%). The other salinity types occupy much less of the Reserve’s saline land, as follows: coulee bottom (4.5%), canal seepage (1.3%), slough ring (0.3%) and artesian (0.3%). Based on existing information, it is not possible to identify any areas of natural/irrigation salinity on the Reserve.

Overall, there are many small contact/slope change saline seeps (226 seeps occupying 854 ha (2 110 ac)) and outcrop saline seeps (105 seeps occupying 595 ha (1 470 ac)). The other types of saline seeps are less numerous: 28 depression bottom seeps; 14 coulee bottom seeps; 7 irrigation canal seeps; 3 artesian seeps; and 1 slough ring seep.

Acknowledgements

This salinity mapping and analysis project for the Blood Indian Reserve was managed by the Conservation and Development Branch of Alberta Agriculture, Food and Rural Development. Funding provided by the Conservation and Development Branch, the Canada-Alberta Environmentally Sustainable Agriculture (CAESA) Agreement and the Blood Indian Reserve is greatly appreciated.

The authors acknowledge the contributions made by: Eugene Kurinka, Conservation and Development Branch, for field work; Gerald Stark, Longin Pawlowski and Scott Rudman, Conservation and Development Branch, for preparing diagrams and cover, and plotting the salinity map; Carolyn King, Conservation and Development Branch, for editing the report; and Leon Marciak and Don Wentz, Conservation and Development Branch, for technical review. Comments on the salinity data from Morris Hindbull, Agricultural Manager, Blood Indian Reserve, are greatly appreciated.

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1.0 Introduction

1.1 Goal and Objectives

The goal of this project is to present information on salinity location, extent and type on the Blood Indian Reserve. Soil degradation is a key issue in conservation planning, and salinity is one of the most visible soil degradation problems affecting the Reserve according to its Canada-Alberta Environmentally Sustainable Agriculture (CAESA) Agreement action plan. Therefore this mapping project aims to better define the salinity problem for the Blood Indian Reserve.

The project's goal is achieved through the following objectives:

1. To derive and integrate existing salinity information for agricultural land on the Blood Indian Reserve.
2. To determine the salinity type, based on the mechanism causing the salinity, for saline seeps on the Reserve.
3. To recommend appropriate control methods for each type of salinity.
4. To compile a map depicting salinity location, extent and type.

The project differs from most salinity surveys by specifying the type, exact locations and control measures. This information can be used in municipal and farm conservation planning.

1.2 Methodology

The methodology for mapping salinity was developed for the County of Vulcan by Kwiatkowski et al. (1994). It is being applied to other Alberta municipalities where soil salinity is a concern (see page 24 for a list of reports completed to date). The process of salinity mapping consists of five stages:

1. Scan aerial photographs and digitize saline areas on the Reserve base map. Only saline areas visible on the soil surface are mapped. (The lands surrounding visible saline seeps may have saline subsoils.)
2. Determine the types of salinity occurring on the Reserve, based on hydrogeology, surface water flow, geology, topography, irrigation and soils. Determine appropriate cost-effective, practical control measures based on salinity types.
3. Field check the salinity data and submit the draft salinity information to a technical team consisting of a project manager, hydrogeologist, salinity specialist, and the Reserve’s Agricultural Manager for review.
4. Create a digital data base in ArcInfo format with geographically referenced information on salinity location, type and extent. This data base can be easily managed and transformed into ArcView format. It can be used to create maps and calculate statistics. Additional text and graphic information can be added to the data base as the data become available.
5. Using the digital data base, prepare a colour-coded 1:100 000 map, showing salinity location, extent and type, and a report.

1.3 Information Sources

A variety of maps, aerial photographs and other information sources were used for this project. Information on climate, soils, parent material and geology is from the following soil survey and hydrogeology reports:

- Soil Survey of the Lethbridge and Pincher Creek Sheets, Alberta (Wyatt et al. 1939)
- Hydrogeology of the Lethbridge-Fernie Area, Alberta (Tokarsky 1973).

Aerial photographs from 1992 (scale of 1:5 000) were used to help determine the location, extent and type of salinity on a section-by-section basis. As well, satellite imagery was used, particularly to identify irrigated lands.

To ensure the accuracy of the salinity map, the Reserve was field checked. Local personnel were also consulted to validate the findings.

2.0 Classification of Saline Seeps

2.1 Transportation of Salts

The dominant salts in the Blood Indian Reserve consist of sodium and magnesium sulphates. Analyses of groundwater, saline soils and parent material suggest that the primary source of salts is bedrock, and the secondary source is glacial till (Greenlee et al. 1968). Soils developed on the Bearpaw bedrock formation contain high salt concentrations.

Saline seeps form when saline groundwater rises to the ground surface. Contact and slope change seeps (described in Section 2.2.1) develop when water in a recharge area percolates down through

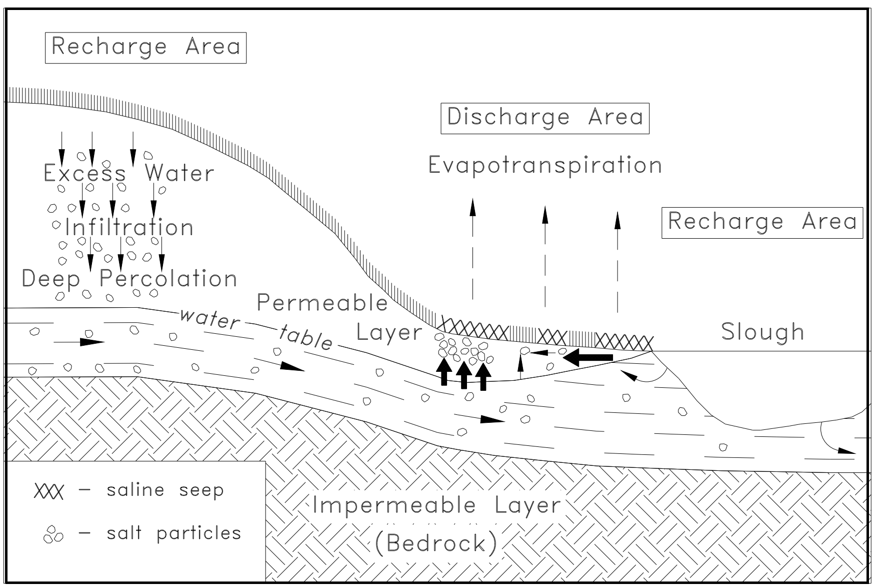


Figure 1. Generalized saline seep mechanisms

the soil profile beyond the root zone and dissolves soluble salts (Figure 1). The water moves laterally to a lower position in the landscape and then rises to the surface, resulting in a saline seep. High evapotranspiration rates encourage the capillary rise and the deposition of salts on the soil surface.

Three different types of flow may be recognized within a groundwater basin: local, intermediate and regional. A local flow system occupies a relatively small area, with the recharge area at a higher elevation than the discharge area. An intermediate system consists of several interconnected local systems. In the Blood Indian Reserve, most of the groundwater flow systems are local, and the recharge areas are within a few hundred metres of their discharge areas. Intermediate flow systems extend beyond 1 km (0.6 miles) of their recharge areas. Regional flow systems extend over several kilometres.

Groundwater movement is influenced by topography as follows:

- In large, flat areas, groundwater movement is minimal or even impeded.
- In areas with well-defined local relief (e.g. hummocky or rolling landscapes), local flow systems are prevalent
- In areas with one large slope, regional and intermediate systems may be prevalent.
- In large valleys, regional systems predominate.

2.2 Salinity Types

Eight salinity types have been identified in Alberta (Kwiatkowski et al. 1994). They can be grouped into six dryland and two irrigation types. The seeps are classified based on hydrogeology, surface water flow, geology, topography, irrigation and soils. Where several salinity mechanisms influence the formation of a single seep, the dominant mechanism is reported. Seven of the eight salinity types occur on the Blood Indian Reserve. The 1:100 000 map in the back-cover pocket of this report shows the distribution of saline seeps by type for the Reserve.

2.2.1 Dryland Salinity Types

1. Contact/Slope Change Salinity

Contact salinity and slope change salinity are grouped together because they cannot be differentiated on aerial photographs and because the same methods are used to control both types (see Section 3.0). The two types are described as follows:

a. **Contact salinity** occurs where a permeable, water-bearing surface layer thins out above a less permeable layer, such as a fine-textured layer (Figure 2). This forces the groundwater closer to the surface. Contact salinity is the most common salinity type on the Reserve, occupying almost 46.5% of the total saline area.

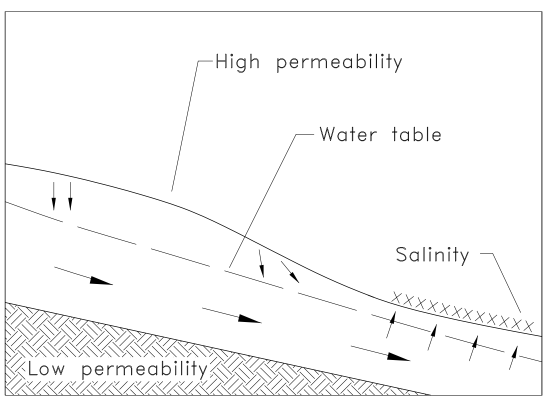


Figure 2. Contact salinity

b. **Slope change salinity** occurs where the slope decreases. This decrease results in a slowing of the groundwater flow and a shallower water table (Figure 3). This type of seep expands upslope. It is a minor salinity type on the Blood Indian Reserve.

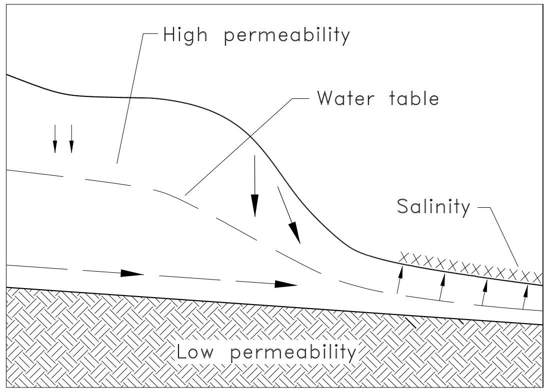


Figure 3. Slope change salinity

2. Outcrop Salinity

Outcrop salinity occurs where a permeable, water-bearing layer, such as a coal seam or fractured bedrock layer, outcrops at or near the surface (Figure 4). Outcrop salinity often occurs along a slope at similar elevations. On the Blood Indian Reserve, this salinity type is the second most common type, occupying 32.5% of all saline land. The bedrock is generally very shallow, providing the conditions necessary for the formation of outcrop salinity.

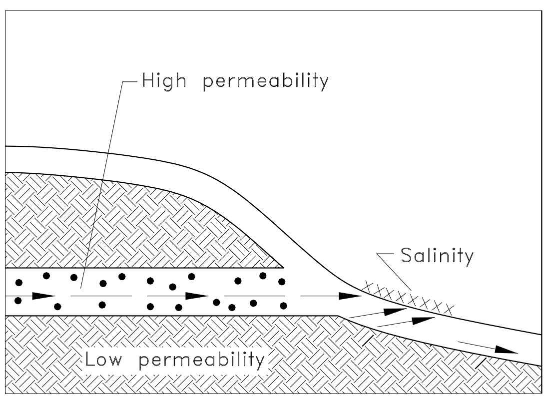


Figure 4. Outcrop salinity

3. Artesian Salinity

Artesian salinity occurs where water from a pressurized aquifer rises to or near the ground surface (Figure 5). It is usually associated with intermediate or regional groundwater flow systems. If the pressure is high enough, the water flows to the surface and produces a flowing well, spring or soap hole. Artesian seeps can be identified from the presence of these flow features in combination with hydrogeological maps. Only three artesian seeps, occupying 0.3% of all saline land, were identified on the Reserve.

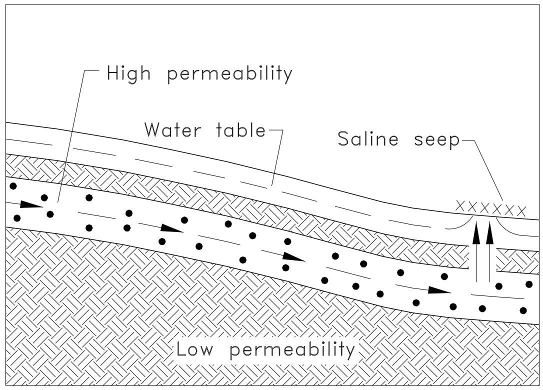


Figure 5. Artesian salinity

4. Depression Bottom Salinity
This salinity type occurs in low lying areas. Surface water is trapped temporarily in these low areas until the water drains off and/or infiltrates the soil. Some water in the soil flows upslope through the upper soil in an unsaturated state and then surfaces to evaporate and deposit salt at the edge of the ponded area (Figure 6). As well, once the surface water has disappeared, groundwater from the water table rises by capillary action to the surface in and around the previously ponded area. Depression bottom seeps are well defined with distinct, rounded edges.

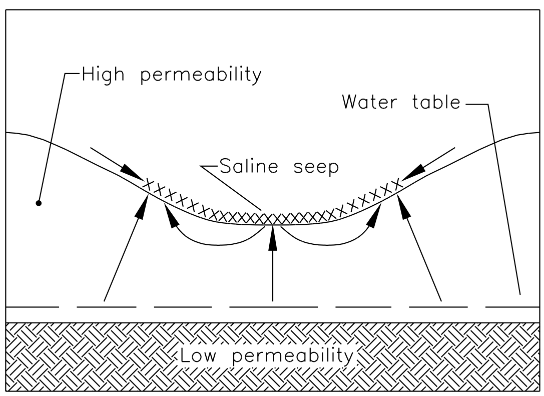


Figure 6. Depression bottom salinity

This salinity type is the third most common type on the Reserve, occupying 14.6% of all saline land. Depression bottom seeps also occur in several landscapes with restricted drainage (ponds and draws), particularly in gently rolling areas. They are also sometimes associated with Solonetzic soils which occur sporadically on the Reserve.

5. Coulee Bottom Salinity
Coulee bottom salinity forms in the bottoms of coulees and watercourses by the same mechanism as depression bottom salinity but on a larger scale. Coulee bottom salinity type typically develops over long periods of time so most of the lands affected by it have never been in agricultural production. On the Blood Indian Reserve, coulee bottom salinity occupies 4.5% of all saline land.

6. Slough Ring Salinity

This type of salinity occurs as a ring of salt immediately adjacent to a permanent water body (Figure 7). Water infiltrates from the water body into the permeable upper soil layer and flows upslope through this layer as shallow groundwater in an unsaturated state. The water may also flow downward, raising the water table. Water from the unsaturated flow and water raised from the water table by capillary action emerges at the surface where it evaporates, leaving salts at the edge of the slough. This type of salinity is often associated with Solonetzic soils. On the Blood Indian Reserve, slough ring salinity occupies only 0.3% of all saline land.

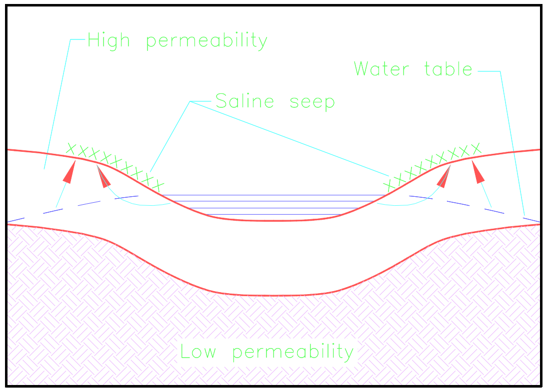


Figure 7. Slough ring salinity

2.2.2 Irrigation Salinity Types

1. Canal Seepage Salinity

This type of salinity is dominant in irrigated areas where leakage from canals contributes to seeps (Figure 8). Because many canals are located along a topographic break, canal seepage often aggravates natural salinity. On the Blood Indian Reserve, canal seepage salinity occupies 1.3% of all saline lands.

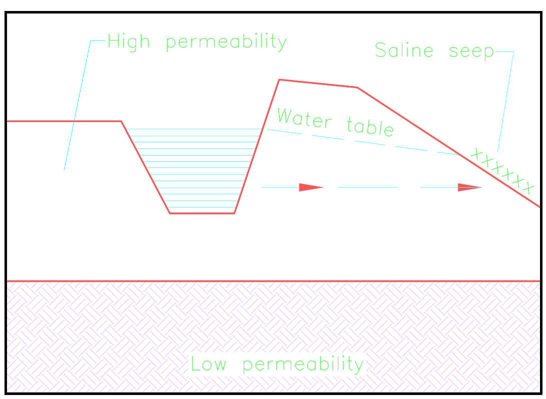


Figure 8. Canal seepage salinity

2. Natural/Irrigation Salinity

These seeps result from one or more of: natural seepage, canal seepage and excess irrigation. All seeps located on irrigated land and some distance from canals and supply ditches are given this classification. Irrigation is a relatively recent development on the Reserve and natural/irrigation salinity does not occur at present.

3.0 Dryland Salinity Control Methods

Salinity is a complex problem caused by climatic, hydrogeological and agricultural factors. The opportunities for moderating the effects of climate and hydrogeological processes are limited and/or expensive. Therefore appropriate agricultural practices are recommended where possible to help prevent or control saline seeps.

Table 1 summarizes the salinity control measures recommended for each salinity type. The emphasis in this section is on cost-effective, agronomic measures to control dryland saline seeps. Specifically, cropping systems that intercept soil water in the recharge area before the water moves below the crop root zone are recommended. For control of irrigation-related salinity, contact your local Alberta Agriculture irrigation specialist to determine appropriate structural measures (e.g. subsurface drainage, canal lining, cutoff curtains) and/or farm water management measures (e.g. cropping system, water management methods, irrigation methods).

Table 1. Salinity types and recommended control measures

Salinity type	Control
Contact/Slope change salinity	Salt-tolerant grasses in the saline area and alfalfa in the upslope dominant recharge area
Outcrop salinity	Salt-tolerant grasses in the saline area; subsurface water management if appropriate
Artesian salinity	Salt-tolerant grasses in the saline area; relief wells connected to suitable outlets
Depression bottom salinity	Salt-tolerant grasses in the saline area and along the edge of the depression in a band extending an additional 20 to 60 m beyond the visibly saline area; appropriate surface water management
Coulee bottom salinity	Salt-tolerant grasses in the saline area; appropriate surface water management
Slough ring salinity	Salt-tolerant grasses in a band around the slough in the visibly saline area and extending an additional 20 to 60 m beyond; appropriate surface water management
Irrigation canal seepage salinity	Structural controls to prevent canal seepage (canal lining, cut-off curtains), and/or subsurface drainage of affected area
Natural/irrigation salinity	Appropriate structural controls for irrigation-related salinity; salt-tolerant grasses for natural salinity

3.1 Biological Controls for Recharge Areas

Biological controls, including deep-rooted perennials and annual crops, are grown in recharge areas of contact and slope change seeps to lower the water table. The recharge areas of coulee bottom, outcrop and artesian salinity are usually too large or too poorly defined for biological recharge controls to be effective. Depression bottom and slough ring salinity can also benefit from perennial forage cover (see Table 1).

3.1.1 Deep-Rooted Perennial Crops

Deep-rooted perennial crops are preferred over annual crops for seeding in *dominant recharge areas*. Dominant recharge areas are those portions of the entire recharge area that make the greatest contribution to the water table. Annual crops are used in the non-dominant recharge areas of a field and in places where the bedrock is too shallow for deep-rooted crops to be effective or where precipitation is low.

Deep-rooted perennials are seeded in the recharge area to reduce percolation to the water table. This lowers the water table and restores the soil's water storage capacity in the recharge area. As a result, groundwater flow from the recharge area to the discharge area is reduced. As the water table in the discharge area falls, precipitation begins to leach salts down below the seed bed. Gradually the seep is controlled and may even be brought back into annual crop production.

Perennial forages, especially deep-rooted species, are preferred over annual crops for several reasons. Most perennial crops can respond to fall and early spring precipitation while most annual crops cannot. Deep-rooted perennial forages use more water per unit depth of soil and from a greater depth. Perennial forages also increase soil organic matter content, improve soil structure and reduce soil erosion. Legumes, like alfalfa, also increase soil fertility through nitrogen fixation.

3.1.2 Alfalfa

Alfalfa is the preferred perennial for planting in recharge areas because of its deep-rooting capability, high water-use requirement, extended growing season and commercial value. Tap-rooted alfalfa varieties generally have deeper rooting capabilities than creeping-rooted varieties. Tap-rooted alfalfa will use 760 mm of water per year if available. It can root up to 6 m deep over a five- to six-year period, depending on the depth of soil, bedrock and water table. Alfalfa should be used in areas that have ample precipitation and deep soils with a high water-holding capacity. Areas without these factors are better suited to annual crops.

Site selection: Seeding alfalfa into the dominant recharge area of a contact or slope change saline seep is often the quickest and most effective way to control the seep. Most of the region upslope of a contact or slope change seep may be a potential recharge area. Those portions of the upslope area which are dominant recharge areas are often characterized by depressions, watercourses, borrow pits and shelterbelts where water and snow accumulate. Areas with coarse-textured soils or shallow bedrock with a low potential for additional moisture storage, and areas with shallow water tables may also be dominant recharge areas. Dominant recharge areas are on average about three to five times larger than their saline seeps. For slope change and contact seeps, the dominant recharge areas is often close to the seep, typically within 1 km.

Variety selection and establishment: Tap-rooted varieties of alfalfa are generally recommended for recharge control. However, if stand establishment is a concern then creeping-rooted varieties can be mixed with tap-rooted varieties to help fill in the stand. The Alberta Forage Manual (Agdex 120/20-4) provides recommendations for selecting suitable varieties and for establishing forages.

The manual is available from your local Alberta Agriculture office. This information is updated annually in Varieties of Perennial Hay and Pasture Crops (Agdex FS120/32).

Seeding: Alfalfa should be planted as shallowly as possible into a firm, moist seed bed. The recommended seeding rate is about 7 kg/ha. Where possible, plant alfalfa directly into undisturbed stubble to maintain good seed-to-soil contact, conserve soil moisture, and achieve the proper seeding depth. If alfalfa is planted into bare, fallow land, packing is usually required.

Companion crops should be used only if soil erosion is a concern. A companion crop competes with alfalfa for moisture and nutrients, and reduces the vigour of the alfalfa stand. If a cover crop is needed, use half its normal seeding rate.

The most successful time for seeding alfalfa is early spring. Planting can be done in late April or early May because alfalfa is somewhat frost tolerant. Alfalfa can be planted as late as mid June with satisfactory results. However, summer planting on dryland is not usually successful. Planting in late fall after freeze-up is an option, but the soil temperature should be below 2°C to ensure that germination does not occur until spring.

Alfalfa can be seeded using any conventional seeder. Hoe drills and zero-till drills often give good results because of good depth control and packing capability. Disk drills work best if the seed bed is uniform and moderately firm. However, in loose soil disk drills may place the seed too deeply, and in very firm soil they may leave the seed on the soil surface. Both conditions result in poor germination.

Fertilization: Alfalfa can use atmospheric nitrogen through a symbiotic relationship with specific rhizobia bacteria. These bacteria do not exist naturally in Alberta soils. Therefore alfalfa seeds should be inoculated to ensure good stand development (see Inoculation of Legume Crops, Agdex FS100/23-1, for more information). Healthy alfalfa stands with good nodule development should not be fertilized with nitrogen because fertilizing will reduce the vigour of the nodules and more nitrogen fertilizer will then be needed.

A soil test should be done to determine phosphorus needs. Alfalfa requires 5 kg of phosphorus per tonne of yield. The phosphorus application should meet alfalfa's requirements for the life of the stand. For example, if the target yield is 1800 kg/year and the life of the stand is five years, then 45 kg of phosphorus should be available. Phosphorus fertilizer should be deep banded in the fall prior to planting alfalfa in the spring.

Potassium and sulphur are also important nutrients for optimum alfalfa production. A soil test should be performed to determine nutrient needs.

Weed control: Weeds and volunteer annual crops are often a problem when establishing alfalfa. Simply mowing annual weeds and volunteer annual crops at an early stage usually suppresses their growth and allows alfalfa to dominate. The herbicides currently available for in-crop control of broad-leaved perennial weeds in alfalfa may also kill the alfalfa. Therefore, where possible, these weeds should be controlled before seeding alfalfa. Perennial grassy weeds, like foxtail barley, readily invade grass and alfalfa stands. At present, very few herbicides are available for in-crop control of grassy weeds in alfalfa. Alberta Agriculture's Crop Protection with Chemicals (Agdex 606-1) lists herbicides for weed control in alfalfa and other forages.

Stand duration: Alfalfa usually takes about five to six years to reach its maximum rooting depth and lower the water table in the recharge area. This, in turn, gradually lowers the water table in the discharge area. Eventually the water table and salt load in the discharge area will drop below the root zone. Once this occurs, the recharge area should be converted to cereal crops. The recharge area can remain in cereal crop production until the water table in the discharge area begins to rise again. The discharge area could also be planted to an annual crop at this time. However, most producers prefer to leave the discharge area in salt-tolerant forages because of the difficulty in re-establishing a forage crop if the discharge area does re-salinize.

3.1.3 Annual Crops

Annual crops are recommended for planting in non-dominant recharge areas. They can be planted in dominant recharge areas if the bedrock is too shallow for deep-rooted perennial crops to be effective or if precipitation is too low for growing deep-rooted perennials. Although not as effective as a perennial crop, an annual crop has some ability to lower the water table in the recharge area. An annual crop is much better than no crop in the recharge area.

Most of the region directly upslope of a contact or slope change saline seep may be a potential recharge area. For recharge control, continuous cropping is recommended wherever possible. A field should be recropped if stored spring soil moisture and rainfall probabilities are favourable for a positive net return on the crop. The field is fallowed if conditions are not favourable. A field should never be fallowed for two years in a row.

Direct seeding or reduced tillage systems conserve soil moisture and thus improve the potential for recropping in drier areas. Also, spring soil moisture can be increased by snow trapping. Snow trapping methods must distribute snow evenly without forming large drifts because large drifts can cause significant groundwater recharge.

Snow trapping methods include:

- stubble - Stubble traps snow better than bare soil, and tall stubble traps snow better than short stubble.
- shelterbelts - The ability of shelterbelts to trap snow can be manipulated by such factors as species selection and tree pruning. More information on shelterbelt design is available in several Alberta Agriculture publications including Field Shelterbelts for Soil Conservation (Agdex 277/20-3) and Shelterbelt Varieties for Alberta (Agdex 277/33-1)

3.2 Biological Controls for Discharge Areas

Plants provide soil cover and shading to reduce evaporation and thereby reduce the rise of salty water to the surface of the discharge area. Plants also protect soil from erosion. Usually salt-tolerant perennial crops are seeded into discharge areas. However, even a crop residue cover or weeds such as kochia are preferable to bare soil.

Biological discharge controls help to limit expansion of a saline seep, but they cannot bring a saline seep back into annual crop production on their own. These controls are only possible when the salt concentration in the seep is not so high as to completely prevent all plant growth.

3.2.1 Plant Species

Select plant species that can tolerate the amount of salinity in the discharge area. A soil test will give the salinity rating in terms of electrical conductivity (EC). Table 2 shows the relationship between the salinity rating and EC values.

Table 2. Salinity rating and electrical conductivity value

Soil Depth (cm)	Non-Saline	Weakly Saline	Moderately Saline	Strongly Saline	Very Strongly Saline
0 - 60	<2 ds/m*	2 - 4 ds/m	4 - 8 ds/m	8 - 16 ds/m	>16 ds/m
60 - 120	<4 ds/m	4 - 8 ds/m	8 - 16 ds/m	16 - 24 ds/m	>24 ds/m

* ds/m = decisiemens per metre, a unit of measure for electrical conductivity

Table 3 lists characteristics of various salt-tolerant grass species recommended for seeding into saline seeps. Flooding tolerance is usually a requirement because saline areas are often temporarily saturated in the spring. Note that creeping foxtail is only moderately salt-tolerant in the seedling stage and thus will be hard to establish. Also, slender wheatgrass is recommended only when mixed with another grass species. Slender wheatgrass is quick to establish and thus provides good cover while the main grass species becomes established. Slender wheatgrass will die out within two or three years, once the main grass is established. If possible, plant slender wheatgrass and the main species in separate rows.

If the area is highly saline, very salt-tolerant grasses, like Nuttall's alkali grass, are recommended. However, these grasses produce much lower tonnages per acre than wildrye grasses and wheatgrasses. Plants under stress do not perform to their maximum potential.

Note that alfalfa seedlings are not salt-tolerant, even though mature alfalfa is moderately to highly salt-tolerant. Thus alfalfa should not be planted directly into a saline discharge area.

A mix of salt-tolerant grasses may be better than a single grass species in some cases. If the soils in the discharge area are variable, it may be impossible to select a single species to suit the whole area. Also, it is sometimes difficult to select a single species that continues to grow well when moisture and salinity conditions change in the seep. For more information on grass species and mixes, refer to the Alberta Forage Manual.

Table 3. Grass species recommended for seeding into saline seeps

Species	Seeding rate (kg/ha)	Rate of establishment	Sod or bunch	Salinity tolerance*	Longevity	Winter hardiness	Flooding tolerance	Drought tolerance
creeping foxtail	5-10	average	sod	high	long	good	high	poor
meadow foxtail	5-10	average	sod	medium	long	good	high	poor
smooth bromegrass	5-10	slow	sod	medium	long	excellent	medium	good
meadow bromegrass	5-10	slow	sod	medium	long	excellent	medium	good
slender wheatgrass	5-10	very fast	bunch	high	short	good	medium	good
intermediate wheatgrass	5-10	fast	sod	medium	short	excellent	medium	good
pubescent wheatgrass	5-10	fast	sod	medium	short	excellent	medium	good
tall wheatgrass	5-10	fast	bunch	high	long	excellent	high	poor
western wheatgrass	5-10	fast	sod	high	long	excellent	high	good
Russian wildrye	5-10	very slow	bunch	high	long	good	poor	good
altai wildrye	5-10	very slow	bunch	high	long	excellent	medium	good
beardless wildrye	5-10	very slow	sod	very high	long	good	medium	good
Nuttall's alkali grass	5-10	average	sod	very high	long	good	medium	good

* medium: tolerates up to 6 to 8 ds/m; high: tolerates up to 8 to 12 ds/m; very high: tolerates greater than 12 ds/m.
Source: Henry Najda, Alberta Agriculture, Food and Rural Development

Forage mixes: Care should be used in feeding crops grown in saline seeps to livestock. Research by Agriculture and Agri-Food Canada shows that high levels of sulphate and trace metals are common in plants grown in saline seeps. If there is any concern about forage quality, a feed test should be done.

When selecting a grass mix for hay production, choose one that can be easily harvested. Low growing or basal growth grasses are difficult to swath and bale. More information is available in the Alberta Forage Manual.

Select species that are suited to the conditions in the seep and to your grazing needs (refer to the grazing calendar in the Alberta Forage Manual). Wheatgrasses are a good choice for spring pasture due to their lush spring growth but become coarse and rank in the late summer and fall. Wildrye grasses are a good choice for fall pasture. Wildrye grasses usually start slowly in the spring, but produce good forage and cure well on the stem. Mixing wheatgrass and wildrye grass species is not recommended because only half the possible production will be achieved from the pasture. If the pasture is grazed in the spring, the wildrye grass will not provide good grazing. If the pasture is grazed in the fall, the wheatgrass will not provide good grazing.

3.2.2 Seeding

Establishing vegetation on a saline seep can be very difficult. One option is to seed in the fall when the seeps are dry and accessible. Seeding rates for saline seeps should be double those for non-saline areas (see Table 3). In severe situations, sprigging may be an option.

For all types of saline seeps, plant salt-tolerant grasses in an area larger than the visibly saline area to ensure good control. For saline sloughs and depression bottom seeps, plant salt-tolerant grasses in a band around the saline wetlands. This band should cover the visibly saline area and extend an additional 20 to 60 m further.

3.3 Structural Controls

Generally, structural controls lower water tables and improve accessibility in discharge areas faster than biological controls. However, structural controls are usually more expensive than biological controls and are not always totally effective. More importantly, they usually require a licence from Alberta Environmental Protection because of their potential environmental impacts.

Structural controls for discharge areas include surface water management, subsurface water management and relief wells. Structural controls for recharge areas usually involve only surface water drainage.

3.3.1 Surface water management

Grassed waterways can be used to drain excess water ponded in discharge or recharge areas. Their main advantage is the erosion protection provided to the drainage channel by the grass cover and low channel slope. Grassed waterways are typically flat-bottomed with a standard bottom width of 3 m, which allows construction with a grader or scraper. The side slopes are less than 25% (1 m vertical to 4 m horizontal) so the waterways can be easily crossed by farm equipment. The best forage mix for a grassed waterway depends on the nature of the area being seeded. Refer to Watercourse Improvement and Gully Restoration (Agdex 573-5) and Grassed Waterway Construction (Agdex 573-6) for more information on construction, forage mixes and maintenance.

3.3.2 Subsurface water management

Subsurface (tile) drainage involves the installation of perforated, corrugated plastic tubing. Subsurface drainage is not commonly used to control dryland salinity because it is expensive, not suited to all salinity types, and requires engineering design. However, it will satisfactorily lower water tables in dryland seeps if the conditions are right and the system is properly designed, installed and managed.

The purpose of subsurface drainage is to remove water and desalinize the root zone through leaching. Initially subsurface drainage removes groundwater near the drainage tile. Over time, precipitation leaches salts from the root zone, and the subsurface drainage removes the leachate so the salty water cannot rise back up to the soil surface.

Subsurface drainage is more effective when above-average precipitation increases leaching. Leaching of salts can be enhanced with low-moisture-use crops, summerfallow and snow trapping on the drained area.

Subsurface tubing can be installed with various types of machinery. The trenchless plow is the most commonly used. It installs the tubing in a single operation. Automatic laser grade-control equipment may be used to keep the tubing at the correct grade. Bucket-wheel and bucket-ladder trencher machines are also available. These types of machines usually excavate the trench and lay the tubing in one operation; backfilling of the trench is a separate operation. If the seep is extremely wet, a backhoe or even a dragline may be needed. A backhoe and hand laying can be used for small projects, particularly in stony areas, as long as the tubing is at the correct grade.

More information on subsurface drainage is available in the Alberta Drainage Guide (Agdex 725-1 to 725-6). Before construction begins, a detailed engineering plan and cost estimate should be completed for the drainage system. Alberta Agriculture irrigation specialists provide engineering design services for subsurface drainage systems on a fee-for-service basis.

In particular, an engineering design is needed to identify a suitable outlet for the drained water. Depression bottom and slough ring salinity types occur in low areas of the landscape, making it difficult to locate an outlet lower than the seep. Subsurface drainage could be used for controlling some outcrop saline seeps because outlets can be easier to locate and because biological controls are not always effective for controlling outcrop salinity.

3.3.3 Relief wells

Relief wells are costly and require engineering design, but they can effectively control springs and soapholes associated with artesian salinity under certain conditions. The wells should be completed in the pressurized water-bearing layer. In Alberta, these layers may consist of coal, gravel, sand or fractured bedrock. Proper installation requires very detailed soil and groundwater investigations. The relief well may flow free, be pumped, or be connected to a buried drain. Alberta Agriculture irrigation specialists provide engineering design services for relief wells on a fee-for-service basis.

Relief wells can be more effective than subsurface drainage in controlling high water tables. If the quality of the drained water is good, the water could be used for domestic or livestock purposes.

4.0 Saline Seep Distribution on the Blood Indian Reserve

This section describes the number and size of saline seeps for all types of salinity and for contact/slope change salinity on the Blood Indian Reserve. These two examples indicate the general tendencies for the other salinity types.

The Blood Indian Reserve has 384 saline seeps which occupy a total of 1 833 ha (4 529 ac), representing 1.3% of the Reserve's total area. This project depicts salinity which is visible on the soil surface. Most of these visible saline areas are out of agricultural production or have significantly reduced crop yields. However, the effects of salinity on crop yields are not usually limited to the visible saline areas. Often the surrounding lands have saline subsoils, resulting in a greater salinity risk. The salts in the subsoil can rise up into the root zone if weather conditions or cropping practices change. Thus, salinity control practices may benefit crop yields over a much broader area than just the visible seep.

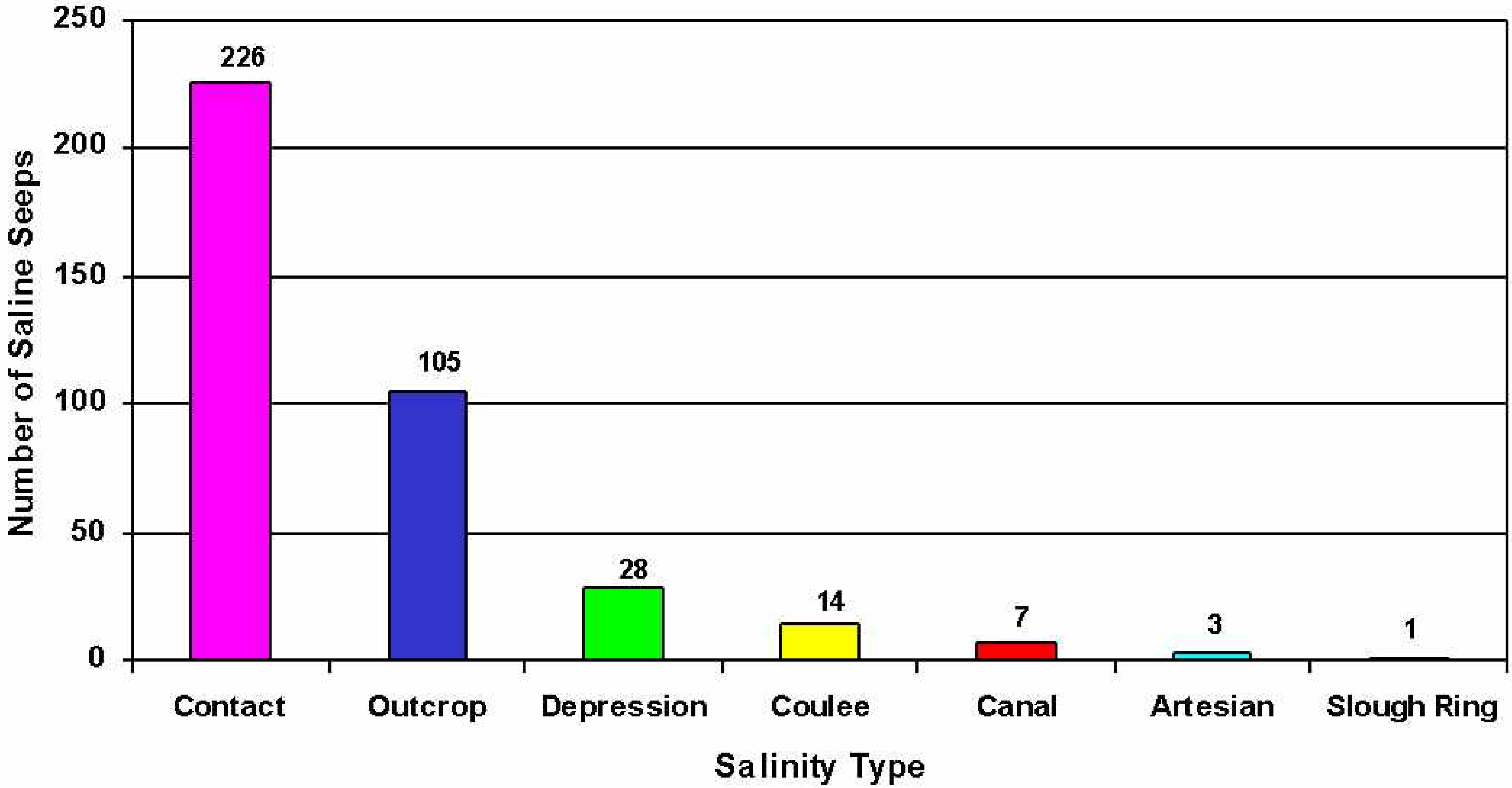
Table 4 presents the number, area and percentage of the total saline area for each of the seven salinity types on the Reserve. Contact/slope change salinity occupies the greatest area (46.5% of all saline land on the Reserve), followed by outcrop salinity (32.5%), depression bottom salinity (14.6%), coulee bottom (4.5%), irrigation canal seepage (1.3%), artesian (0.3%) and slough ring (0.3%). There is no evidence that natural/irrigation salinity occurs on the Reserve.

Table 4. Salinity distribution by type on the Blood Indian Reserve

Salinity type	**Number of seeps**	**Area**		**Percent of total saline area**
		(ac)	**(ha)**	
Contact/slope change	226	2 110	854	46.5
Outcrop	105	1 470	595	32.5
Depression bottom	28	660	267	14.6
Coulee bottom	14	205	83	4.5
Artesian	3	12	5	0.3
Slough ring	1	12	5	0.3
Irrigation canal seepage	7	60	24	1.3
Natural/irrigation	--	--	--	--
Total	384	4 529	1 833	100.0

Figure 9 shows the number of saline seeps by type. Overall, there are many small contact/slope change saline seeps (226 seeps occupying 854 ha (2 110 ac)) and outcrop saline seeps (105 seeps occupying 595 ha (1 470 ac)). The other types of saline seeps are less numerous: 28 depression bottom seeps; 14 coulee bottom seeps; 7 irrigation canal seeps; 3 artesian seeps; and 1 slough ring seep.

Figure 9. Number of Saline Seeps by Type in the Blood Indian Reserve



The average size for all seeps is 4.7 ha, and 62.8% of seeps are less than 3 ha. The smallest seep is a contact/slope change seep with an area of 0.022 ha (0.05 ac), and the largest seep is a depression bottom seep with an area of 67.5 ha (167 ac). Figure 10 shows the frequency of different size ranges for all saline seeps. Twenty-eight percent of seeps (108 seeps) are larger than 4 ha. The larger seeps are coulee bottom and depression bottom seeps.

The areas for contact/slope change saline seeps are shown in Figure 11. Of the 226 contact/slope change seeps, 50% are between 0 and 2.0 ha (0 and 4.9 ac). The recommended measures to control contact/slope change salinity are to grow salt-tolerant grasses in the saline area and alfalfa in the dominant recharge area. On average, dominant recharge areas are about three times the size of their saline area. Thus, as a general guide, an area about three times the size of the seep will need to be converted to alfalfa to control contact/slope change seeps.

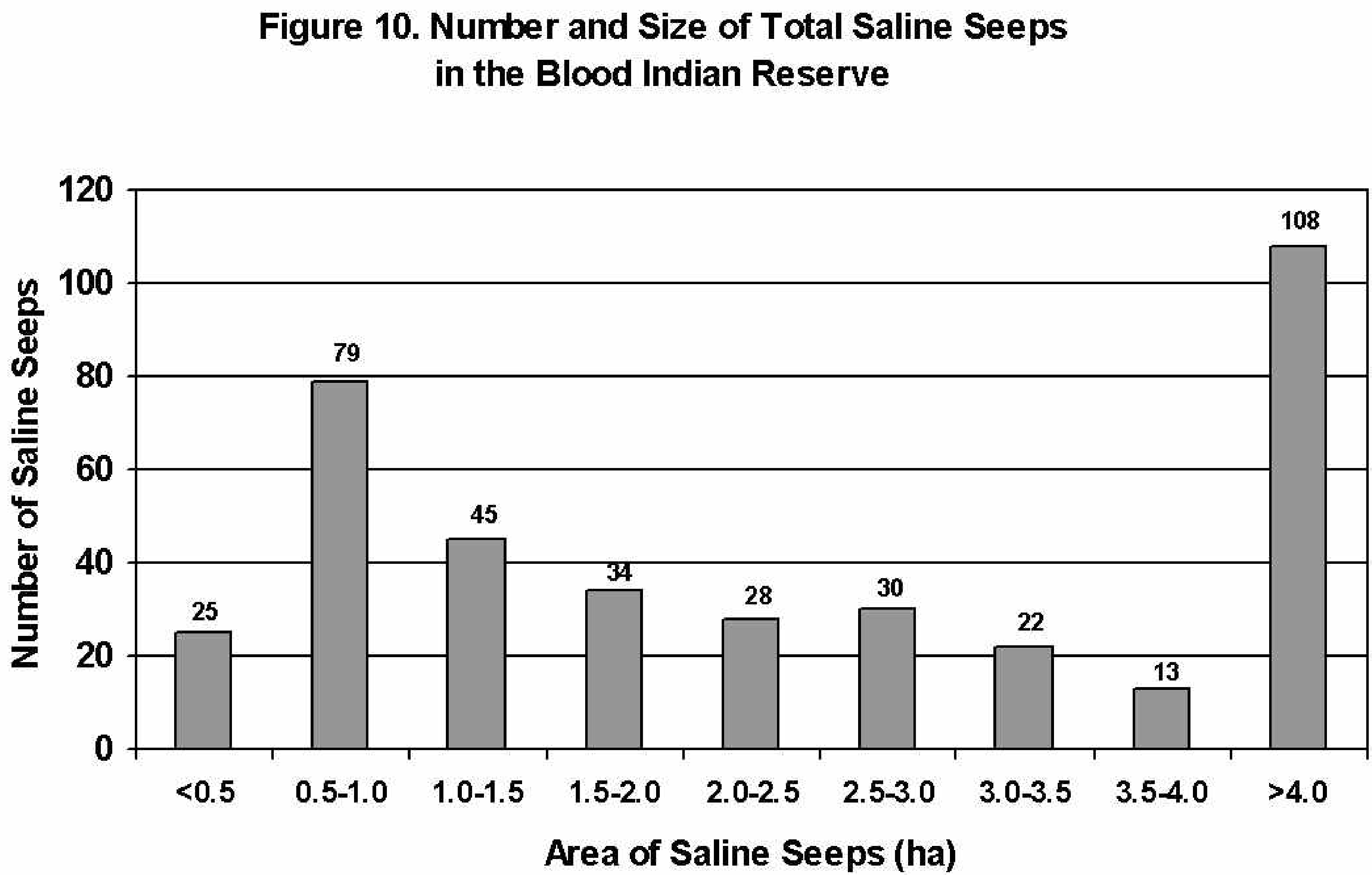
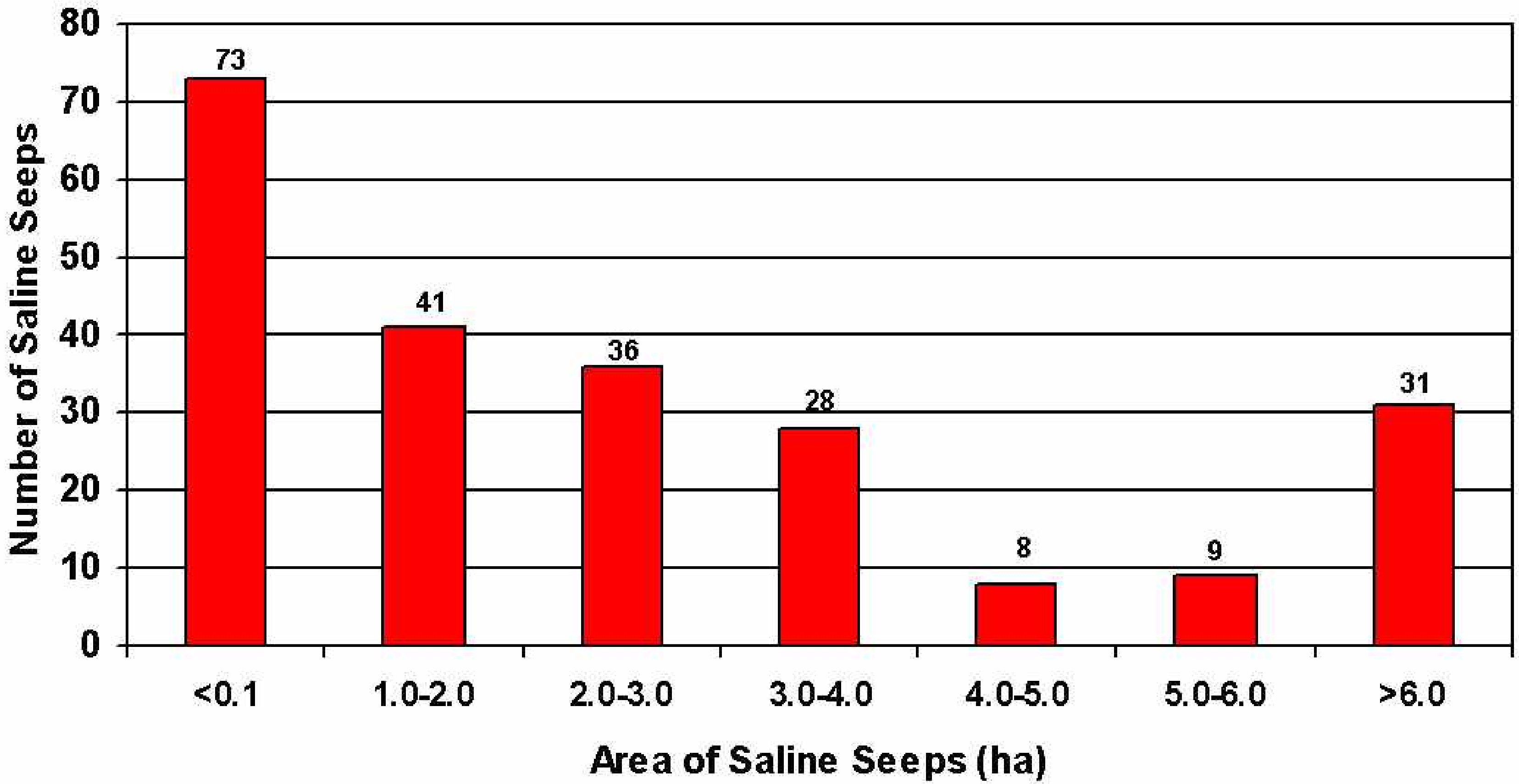


Figure 10. Number and Size of Total Saline Seeps
in the Blood Indian Reserve
Number of Saline Seeps
120
100
80
60
40
20
0
25
79
45
34
28
30
22
13
108
<0.5
0.5-1.0
1.0-1.5
1.5-2.0
2.0-2.5
2.5-3.0
3.0-3.5
3.5-4.0
>4.0
Area of Saline Seeps (ha)

Figure 11. Number and Size of Contact/Slope Change Saline Seeps in the Blood Indian Reserve



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Glossary

Aquifer - A body of earth material capable of transmitting water through its pores at a rate sufficient for water supply purposes. (Vanderpluym and Harron 1992)

Artesian groundwater - Groundwater confined under pressure so that water rises up in a non-pumping well which penetrates it.

Bedrock - The solid rock that underlies the soil and regolith or that is exposed at the surface. (Agriculture Canada 1976)

Capillary action - The action by which the surface of a liquid, where it is in contact with a solid, is elevated or depressed depending on the forces of adhesion and cohesion.

Electrical conductivity - A method of expressing salinity. An electrical conductivity (EC) measurement can be used to determine the salt content of soil in a saturated soil paste extract. The EC value is usually expressed in decisiemens/metre (ds/m). For example, topsoil with an EC value of 2 ds/m is considered non-saline; topsoil with an EC value of 16 is very saline.

Groundwater - 1) Water that is passing through or standing in the soil and the underlying strata. It is free to move by gravity. (Agriculture Canada 1976). 2) Water in the ground that is in the zone of saturation, from which wells, springs and groundwater runoff are supplied. (Vanderpluym and Harron 1992)

Parent material - The unconsolidated and more or less chemically weathered mineral or organic matter from which the solum of a soil has developed. (Agriculture Canada 1976)

Permeability, soil - The ease with which gases and liquids penetrate or pass through a bulk mass of soil or a layer of soil. (Agriculture Canada 1976)

Saline soil - A non-sodic soil containing enough soluble salts to interfere with the growth of most crop plants. The conductivity of the saturation extract is greater than 4 ds/m (at 25°C), the exchangeable sodium percent age is less than 15, and the pH is usually less than 8.5. (Agriculture Canada 1976)

Seepage - 1) The emergence of water from the soil over an extensive area, in contrast to a spring where water emerges from a local spot. (Agriculture Canada 1976). 2) The slow movement of water through small cracks, pores, interstices, etc. of a material into or out of a body of surface or subsurface water. (Vanderpluym and Harron 1992)

Till - Unstratified sediment deposited directly by a glacier and consisting of clay, sand, gravel and boulders intermingled in any proportion. (Agriculture Canada 1976)

For further information, please visit www.agric.gov.ab.ca

Other Municipal Salinity Mapping reports for Alberta (as at 1997)

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