the standpoint of economy and efficiency. Haphazard location increases the amount of material to be moved, both in the main drain and in the laterals which tap the adjacent areas. Again, a poorly located ditch fails to receive the surplus water from areas which might readily be drained into a properly located ditch. A hastily located drain is most unfair to the farmer. The cost of the little extra time required to make an efficient location is repaid many times by the larger area drained and a decreased yardage.

Even in the most rolling country the surplus water at flood time follows a certain main line of flow. This course should in general be adopted as the centre-line of the main ditch. It occasionally happens, however, that large sloughs may be more easily drained by a short heavy cut than by the line of natural flow. The expediency of either course is easily determined. Abrupt turns should be avoided in a drain and a general straightening of the course will give a ditch of maximum efficiency. In the small ditches at present under consideration in Saskatchewan no curvature greater than 10° should obtain. Experience has shown that any greater degree of curvature seriously impairs the usefulness of the ditch.

There is a popular fallacy among farmers to the effect that ditches drain off needed water in time of drought. It must be borne in mind, however, that only the hydrostatic water drains into the ditch, the capillary water always remaining to do its work. Ditches, therefore, work no injury during the time they are not needed, and are a necessity at other times, their value at such times being measured by their ability to receive the surplus water necessary to save the lands and crops from injury.

The centre-line of the ditch having been established, the area of the cross-section necessary to carry the water must be determined. A simple formula, applicable to conditions in Saskatchewan, is given by the chief of the Reclamation Bureau of the United States. It is considered, for ordinary drainage schemes, to give as good results as the more involved formulae which may be found in the various text books on the subject. The area may be determined from

$$v = \sqrt{\frac{a}{p}} \times 1\tfrac{1}{2}f, \text{ and } Q = av$$

where a = to area of waterway,
p = wet perimeter,
f = fall in feet per mile, and
Q = discharge in cubic feet per second.

Also, $A = \frac{Q}{n}$ where A = number of acres and n = number taken from table given below.

Table of cu. ft. per sec. which must be discharged from a drain to relieve one acre of land of various depths of water in twenty-four hours:—

Cu. ft.	Inches per acre.	Cu. ft.	Inches per acre.
.0420	1	.0140	1/3
.0315	3/4	.0105	1/4
.0210	1/2	.0052	1/8

It may be mentioned that ½ inch per acre is the generally accepted standard for the prevailing conditions.

Q must first be determined, and, knowing the number of acres in the drainage district, this amount is easily determined from the above formula. With the value of Q fixed, a is assumed and by trial in the above formula one determines if the assumed value is correct. A few trials will give the proper value for a.

With the area of the cross-section of the ditch known, the proportions of the cross-section, the second factor in the process of design, must next be determined. The relation of the depth of the cut to the width is influenced by several independent factors, of which the most important are: Lateral drainage; levels of the surrounding country to be included in the drainage system; and, character of the soil.

Where subsidiary drains are few, as in Saskatchewan, good lateral drainage is obtained with a minimum cut of not less than seven feet. This alone would seem to indicate that the drains should be of minimum width and maximum depth.

Areas requiring drainage usually have a great number of depressions whose levels closely approximate those of the main drain. In order to drain these, considerable cut in the main drain is essential. In this respect it should be pointed out that areas which to the eye appear capable of drainage, are found upon construction of the drain to be below the drainage level. The farmer, however, has been unjustly assessed for an assumed improvement. It is, therefore, important that the engineer take the levels of all parts of the area to be drained. Such levels will also assist in establishing the grade of the drain.

Although the need of lateral drainage and the topography of the drainage areas necessitate a deep cut in the main drain, the soil in the side walls of the drain, on the contrary, retains its position much better in a shallow cut. The decrease in the rate of flow in a wide shallow cut as compared to a deep narrow one, minimizes the danger of erosion. A cave-in in a shallow cut is not nearly so liable to occur as in a deep one, and when it does occur does not offer nearly so serious an obstacle to the water flow.

The determination of the grade constitutes the third factor in the process of design. Obviously, the grade of a drain is, broadly speaking, determined by the natural fall of the country.

In most large drainage areas it is a difficult matter to obtain sufficient fall to ensure an adequate flow. In Saskatchewan, on the contrary, the grade is so steep as to cause considerable danger from erosion. With such rapid fall in the case of a narrow cross-section the ditch is bound to be self-cleaning. A fall of approximately four feet per mile will make the ditch self-cleaning and the fall in the Saskatchewan drains is, as a rule, much more than four feet.

If the grade line be set to make a very light cut in the bottom of each slough intercepted by the drain it will usually be found that there is a series of heavy cuts on the intervening ridges. Therefore, although one might have a more efficient drain by excavating to such a depth of cut in a slough that the banks would not overflow at this point in flood time, it will be found impracticable to deepen the cut to any appreciable extent at such points on account of the extremely rapid increase of the quantities of material to be removed for the correspondingly trifling extra depth obtained.

Where the fall is as great as described, precaution should be taken to prevent washes which when once begun are most difficult to control. Ditches should discharge into a coulee, river or other outlet without an overfall or abrupt drop, since a drop causes a continual sloughing off and cutting back of the channel. They should, if possible, discharge into the usual water line of the latter, the drop being taken up by means of a gradual slope. Much silting