THE PROGRESS AND POSITION OF IRRIGATION IN NEW SOUTH WALES.

By H. G. McKINNEY, M.E., M. Inst. C.E.,
Chief Engineer for Water Conservation.

[*Read before the Royal Society of N. S. Wales, December 6, 1893.*]

IT is not generally realised that notwithstanding the remarkable succession of good seasons which this Colony has enjoyed since 1888, irrigation is being more widely adopted every year, and its benefits are becoming better understood. The wet seasons have in a number of cases, led to a diminution of the irrigated areas in the Eastern and Central Divisions in recent years, but the number of irrigation plants has increased, and there are strong indications of a more rapid increase in the near future. The importance of developing the export trade is beginning to be generally understood, and as a natural consequence every means of increasing the productiveness of the land is receiving increased attention. Irrigation is, however, still in its infancy here, so that it is not necessary to go far back in tracing its development.

When, as a visitor from India, I first travelled over the plains in the southern and south-western districts, about seventeen and a half years ago, the miserable appearance of the herbage where any was to be seen, and the numerous skeletons of sheep and cattle to be seen in all directions, showed much better than any words could do, the necessity for providing means for sustaining the live stock in dry years. When I ventured to suggest to some enterprising and successful pastoralists, that it would be well worth while to try irrigation of fodder crops at suitable places in their runs, these pastoralists, with all the assurance of superior knowledge informed me that such a suggestion coming from an Anglo-Indian who did not understand the conditions of labour in Australia was not surprising; but that in reality it was absurd to entertain the idea of carrying on irrigation with profit in these

colonies. A second visit to the south-western plains showed that these same pastoralists had come to the conclusion that the absurdity was all on their side. In fact some of those who in 1876 had ridiculed the idea that irrigation might prove profitable in the western districts of this Colony had themselves adopted that means of reducing the losses occasioned by lack of rainfall. This change of ideas had occurred without any appreciable alteration in the conditions of labour.

Doubtless, questions connected with the tenure of the land had an important effect in curbing enterprise and preventing the adoption of any course which would tend to show the value and productiveness of the land. There was certainly abundant evidence in 1876 that the pastoralists in the Murrumbidgee and Murray Districts were not wanting in enterprise in regard to providing water for their stock. The Burrabogie run near Hay, now the property of Mr. Wentworth, but then the property of Messrs. McGaw & Co., was perhaps as good an instance as could then be found in the Colony of the extent to which the stock-carrying capacity of the land could be increased by the adoption of suitable means for conserving and utilising the available supply of water. Dams, tanks, and wells were extensively used, and with them a remarkable variety of water-lifting appliances from the centrifugal pump to an ingenious adaptation of the balance lever worked by horse power. In short, throughout the districts adjoining the Murrumbidgee and the Murray, a very creditable amount of enterprise and ingenuity was shown in providing water for stock requirements; but the idea that irrigation was financially feasible, even with the drought then prevailing, was universally scouted.

A settler from one of the Western States of America would scarcely credit the statement that men of intelligence and enterprise under such conditions, would hold such opinions. The explanation is, however, not difficult to find. The policy adopted in the Western States of America was to sell the land at a price little more than nominal, and to grant to the purchasers extensive

rights to river waters free of charge. In New South Wales, immense areas of land were sold to pastoralists above their true market value, the purchasers being practically compelled to buy to prevent their runs from being ruined by selection. Where the land was not sold to the pastoralists, the conditions of tenure were not such as to encourage the runholders to develop the capabilities of the soil. While charging a higher price for the land or letting it on terms which did not encourage its development, the Government of this Colony conceded no rights whatever in regard to river waters. The results of these widely different policies in this Colony and in the Western States of America are such as might have been anticipated from the commencement thus made. The landowners in the Western States soon understood what a valuable property they had in the waters of their rivers, and they lost no time in turning this property to account. Having obtained their land at a very moderate cost, they were the better able to proceed with works for increasing its productiveness. Not having a Government which they could look to for assistance with any hope of obtaining it, they quickly learned how to help themselves. Thus in Wyoming, which became a State only in 1891, and which has a population of only 65,000, the sum of ten million dollars, or say two millions sterling, has been expended on the construction of channels for diverting water from the rivers. In 1889, before this Territory was constituted a State the area of irrigation was nearly 230,000 acres of crops, without reckoning irrigated pasture land. The total area of crops irrigated in the year mentioned in what is termed the Arid Region in the Western States of America amounted to over three and a half million acres. In this Colony the landowners, by constructing tanks, dams, and wells have made provision—in some cases sufficient, in others not so—for watering their live stock ; but as they cannot obtain any legal authority for increasing the stock-carrying capacity of their holdings, by irrigation, comparatively few are willing to incur the necessary risk and expense.

What the landholders of New South Wales and the Colony at large, lose by this backward state of irrigation may to some extent

be inferred from the returns of the United States Census Office. In a report of that office, dated 20th August, 1892, the following passage occurs :—"The average value of the land irrigated in 1889 with the improvements thereon, is found to be $83·28 per acre, and the average value of products for the year stated $14·89 per acre. By correspondence with over 20,000 irrigators, fairly distributed throughout the arid and subhumid regions, it has been ascertained that the average first cost of irrigation is $8·15 per acre and the average value placed upon the water rights, where separable from the land, $26·00 per acre, or over three times their original cost. The average annual expenditure for water, as distinguished from the purchase of water rights, is $1·07 per acre, and the average cost of the original preparation of the ground for cultivation, including the purchase of the land at the Government rate of $1·25 per acre, is $12·12 per acre. By applying, with necessary modifications, to the enumerator's returns, the averages obtained for each separate State and Territory, it has been found that in round numbers the total investment in productive irrigation systems utilized in 1889, in whole or in part, was up to June 1st, 1890, $29,611,000. Their value at that date was $94,412,000 showing an apparent profit of $64,801,000, or 218·84 per cent. In the same manner the aggregate first cost of the irrigated areas with their water rights, not including the farms of the subhumid states, has been ascertained to be $77,490,000, and the value of the same on June 1st, 1890, $296,850,000, showing an increase in the value of land and water rights of $219,360,000, or 283·08 per cent. In other words, the land irrigated in 1889 was worth nearly four times what it cost, no allowance evidently being made for failures. The total expenditure for water, including the maintenance and repairs of ditches, in the arid states in 1889 was $3,794,000 and the total value of products $53,057,000."

It is quite beyond question that the development of this Colony and especially of the fertile plains west of the Dividing Range, is and has been seriously retarded through want of suitable legislation on the subject of water rights and the utilisation of our

rivers. On the other hand, it is equally beyond question that legislation or legalised customs of a somewhat reckless character have given an unhealthy stimulus to the construction of channels for diverting water from the rivers of the Western States of America. The ill-considered design and wasteful working of many of the channels was referred to in Mr. Deakin's interesting and instructive report on American Irrigation. These faults are doubtless due in a large measure to the haste involved in acting on the principle "first come, first served." The working of this principle in Colorado, and of the useful modification of it adopted in Wyoming, has been described as follows :—"In Colorado, A taps a stream and runs his ditches as far as he pleases. Then B taps the stream above A and runs his ditches in the same or another valley or locality. Farming is carried on along both sets of ditches ; but when there exists a scarcity of water, A appeals for his priority rights and gets all the water his ditches will carry. B has his ditches closed, and the orchards and gardens and grain fields along his ditches must die of drought, even though A's territory may not be all under cultivation, or though he may have twice the water he needs. Under the Wyoming system, priority rights prevail, but only water that is actually benefiting land is at any man's disposal." I may here remark parenthetically, that I have never been able to discover on what grounds the Americans apply the term "ditch" to an irrigation canal or distributary. If this term were used regarding American irrigation channels by a hostile critic, the meaning would be obvious, though in many cases the application would be unfair, as there are many American irrigation canals which certainly do not deserve to be called "ditches."

The wholesale waste, both in water and the cost of construction of works, arising from such a system as that described is at once apparent. With reference to this, an American might very pertinently ask us whether such a state of affairs is not preferable to the backward condition of this Colony through want of suitable legislation. On the one hand we have in Western America

wholesale waste and extravagance, due chiefly to the haste with which settlers naturally avail themselves of their water rights; but to counterbalance this waste, there is the great progress of agriculture and of horticulture. On the other hand in New South Wales the development of agriculture and horticulture has been greatly retarded, owing to the fact that no person has any right to use the river waters for irrigation. The free use of the river waters in Western America has led to remarkable progress in the cultivation of the land, but it has created objectionable monopolies, has caused much useless expenditure through ill-considered design and faulty construction of works, and has laid the foundation for endless disputes and litigation. Mr. Deakin has described how in California and Colorado, canals were constructed without engineers and even without surveys. Under such circumstances it is not surprising to find a more recent writer on the same subject, stating that he saw on a map of one of the counties in Wyoming a place where, to use his own words, "one hundred and fifty ditches, paralleled and duplicated one another in land which two ditches would have served thoroughly well." A comparison of Mr. Deakin's report on Irrigation in America with his recent admirable work on Irrigated India is very instructive on this and kindred points.

Notwithstanding the exceptionally favourable seasons which this Colony has lately experienced, and the absence of any legal right to irrigate from our rivers, the spread of irrigation since 1884 has been much greater than is generally supposed. In that year the Royal Commission on the Conservation of Water was appointed under the presidency of the present Minister of Works, Mr. Lyne. Up till that time, with a very few exceptions, irrigation in New South Wales was practised only by Chinamen, who in this respect may, and very possibly do, claim to have been the pioneers of civilisation. Now there are pumping appliances for irrigation purposes to be found on every important river, and on a number of creeks and lagoons west of the Dividing Range; and not only so, but even in the coast district, irrigation, particularly

of orchards, is regularly carried out. This is highly encouraging progress, especially when it is borne in mind that since records of the rainfall and of the river levels began to be kept no such succession of wet seasons as we have lately been favoured with was ever experienced. In a number of cases in which irrigation of fodder crops was carried on in dry or ordinary seasons, such irrigation has in recent years been wholly or partially suspended ; but this is more than counterbalanced by the increase in the number of cases in which pumping machinery for this purpose has been brought into use and by the extension of knowledge of the subject and its importance.

During three years, from 1889 till 1892, prizes were awarded by the Government for the best irrigated farms and orchards. Having had the honour of being one of three judges in the first of these years, and sole judge in the other two, I had excellent opportunities of observing the progress which is being made. The competitors west of the Dividing Range represented properties on the Namoi, Lachlan, and Murrumbidgee Rivers and the Gilmore Creek, a tributary of the Tumut River. Those east of the Dividing Range represented the Hawkesbury, the Parramatta, and the Bega districts. From some cause or other a number of irrigators, particularly on the western rivers, did not compete, although their properties would have attracted favourable notice if they had been entered. The properties which were entered showed in a number of instances a highly creditable class of work, and showed also that the irrigators had the ability and judgment to select the methods best adapted to their circumstances.

The properties entered, though not numerous, embraced orchards, mixed farms, and farms specially intended for providing fodder on pastoral estates. In some cases the conditions were all in favour of the irrigators, but in others it was surprising that irrigation was ever attempted. The most remarkable case of irrigation under difficult circumstances which I have seen, was that successfully carried out by Mr. Wren, Manager of the Kameruka Estate near Bega. As a considerable quantity of fodder was required on

that property, and a stock of it had to be maintained, Mr. Wren went into the question whether he could produce lucerne hay in a central position in the estate. He came to the conclusion that he could do so with advantage, notwithstanding the serious difficulties to be overcome. Owing in a great measure to the high cost of carriage, lucerne hay could seldom be obtained for less than £6 per ton, and had cost as much as £8 per ton. The problem to be solved was how to produce lucerne hay at a lower cost than this on land which consisted of low but steep hills without any intervening valleys. A good supply of water was available, but the soil on these hills was only from five to nine inches deep, underlaid by disintegrated granite, the depth of which was seldom less than two to three feet, and as a rule was considerably more. Under these unpromising circumstances not only were good crops of lucerne of a high quality obtained, but on account of the admirable manner in which the water was distributed, the crop was more even than almost any crop of lucerne I have ever seen on the plains. The secret of this uniform distribution of the water lay in the fact that the channels were skilfully marked out with the aid of a simple but effective water level, which was made by Mr. Wren's engineer, and were constructed in a proper manner. As a rule, in the construction of distribution channels in these colonies and America, economy in first cost is attained with considerable sacrifice of efficiency and economy in the subsequent working. At Kameruka, the channels were neatly cut with the Hornsby draining plough, and very little hand dressing was required. The water had to be raised two hundred and forty-six feet, and the pumping plant was guaranteed to deliver 30,000 gallons per hour at that height. The circumstances here were most exceptional, and though the experiment was successful and satisfactory, it is unlikely that irrigation will be attempted in many other cases where like difficulties exist.

Another irrigated property in which I found features of a somewhat unusual character was the farm in the pastoral estate of Mr. Wills Allen at Gunnible, near Gunnedah. Here also the

chief crop irrigated was lucerne, but maize and other grain crops were grown successfully. This is a class of irrigation which deserves to be widely imitated, as on it will depend, in an important degree the increase of production and settlement on our western rivers. The source of supply in this case is the river Namoi, and the water is raised by a centrifugal pump to a maximum height of slightly over thirty feet. This is one of those cases in which economy in the construction of distributary channels has been carefully considered, while economy in water has been left out of account. The style in which the irrigation is done would not be allowed on any canal in Upper India—in fact it is just such a case as would be deemed to require the application of the penal clause in the Canal Act relating to waste of water. Yet the result is highly successful and no one is at present injured by the extravagant use of the water. The soil is of a very porous character and is underlaid by drift and shingle, so that the natural drainage leaves nothing to be desired, and no damage is done by over-watering. On the contrary, as the water contains certain fertilizing properties, the land is really manured as well as watered by the copious floodings. All this has been taken into account, and there is no doubt that the results obtained amply justify the practice adopted. Not only is the supply of water actually used with the crops unusually large, but there is extensive loss of water in the distributary channels. Like the case of the pumping, this also was a matter which was carefully considered by Mr. Wills Allen, who came to the conclusion that the broad and shallow channels while wasteful of water, were, as compared with channels constructed on more scientific principles, a source of convenience and economy in working his irrigation paddocks. Viewed in this light, the position was a perfectly sound one. The results of the irrigation are highly satisfactory, and the system followed is undoubtedly warranted by the circumstances, though there are many places in which such watering would kill the crops, and others in which it would turn the land into a marsh.

In the Central and Western Divisions, wherever a supply of water is available, irrigated gardens and orchards are to be seen

beside the homesteads of a large proportion of the landowners. But in addition to this, irrigation has been in many places successfully adopted by professional fruitgrowers. In the western districts it may be stated that as a rule fruit cannot be grown except by this means, but it is somewhat surprising that the best managed irrigated orchards which I have seen are in the coast district. It is improbable, however, that this supremacy will be long maintained. When the owner of an orchard ten acres in extent spends nearly £200 on a steam boiler, pump, and piping for irrigation, and finds that his outlay gives a highly profitable return, there is clearly a good field for such enterprise and a fair margin to allow for mistakes. Such outlay under such circumstances has actually been incurred in several instances in the coast district and with the result stated.

In connection with irrigation of orchards it may be here mentioned that great advantages to intending irrigators are likely to be obtained in the Irrigation Trusts at Hay, Balranald, and Wentworth. The Municipal Council of each of these towns has been constituted an Irrigation Trust by special Act of Parliament and in each case a highly valuable grant of land has been given free by Government for subdivision among intending settlers. The Trusts have to obtain the necessary pumping plant for raising the water, and have to construct the works for its distribution. The settlers will be required to fulfil certain reasonable conditions as to residence and cultivation and to pay interest, working expenses, and sinking fund. The present time is very unfavourable for starting new enterprises like these, but there is a strong probability that notwithstanding this fact two of these Trusts will soon be in a position to commence operations.

The question of utilising for irrigation the surplus water from artesian bores, is one with which I had to deal when it first attracted attention, three or four years ago. I then suggested the advisability of using the available supply of water at every artesian bore for the purpose of raising crops—fodder by preference—which might be required in a time of drought. The district

beyond the River Darling, in which nearly all the successful artesian bores are situated, is not likely to be used to any considerable extent for other than pastoral purposes. This being so the object to be aimed at here is the increase of the stock-carrying capacity of the land. The attainment of this object depends mainly on the provision of an ample supply of water for the stock and of reserves of fodder for assisting in tiding over dry seasons. Throughout a large portion of the north-western district, these requirements can be met in part by artesian supplies of water. There is therefore, strong reason for drawing on these supplies to their fullest extent, and making use of them to the greatest advantage.

As already mentioned, irrigation in connection with pastoral properties has in some cases, particularly in the Central Division, diminished in recent years owing to the exceptional rainfall. Since 1886 the record of maximum annual rainfall has been twice broken, namely in 1887 and 1890; not only so, but, with the exception of 1888, every year since the beginning of 1887 has been above the previous average in regard to rainfall and to floods in the rivers. A resident of the Gwydir district of twenty-seven years' standing, lately informed me that during the whole of that period there was no such succession of floods as that experienced in the last few years. The most sanguine will scarcely expect this state of affairs to last much longer. Since the last severe drought the number of sheep in this Colony has nearly doubled, other live stock have increased very largely in number, and the importance of agriculture, dairying, and fruit growing have advanced in at least a corresponding degree. Under these circumstances the question suggests itself, "How are we now prepared for a drought"? This is a question of the first importance and one which requires to be examined from several points of view.

In the last ten years the number of sheep in this Colony has increased from 36,115,000 to 58,080,000, and other live stock have also increased largely, though not in the same proportion. Selectors in the Central Division and homestead lessees in the Western Division constitute an important increase in the number

of settlers. While the seasons have, on the whole, been unusually favourable, the low prices for wool and for live stock and produce generally, and the loss and expense caused by rabbits, have, in many cases, more than counterbalanced the benefits which might have been expected from increased rainfall. Bearing these facts in mind, and also taking into account the present state of the money market, there is no doubt that regarded from the purely financial point of view, the Central and Western Divisions are not so well prepared for a drought as they were ten years ago.

There is another point in regard to which the Western Division particularly has deteriorated; namely the quantity of edible scrub. When grass was not to be had, the rabbits quickly discovered all the most useful and nutritious kinds of edible bushes and scrub, and they sustained themselves on the bark of these and as much of the leaves as they could reach. In this way the edible scrub was killed over very extensive areas, and in a number of instances the resumed areas of pastoral holdings were abandoned by the lessees, largely on this account. As a striking instance of depreciation of the value of pastoral holdings owing to the presence of rabbits, and to the destruction caused by them, it may be mentioned that in March 1892, a station in the south-western part of the Colony, comprising about 1,200 square miles of country and including 5,000 acres of freehold land with a good woolshed, homestation and garden, and 10,000 sheep, fifty horses, and fifty head of cattle was sold for £3,250.

Thus, as compared with the position ten years ago, we have a largely increased number of live stock, diminished carrying capacity of large areas of country, and a much more stringent money market. But on the other hand, railway communications have increased largely during that period, and the facilities for transferring live stock from one part of the Colony to another have increased in a corresponding degree. This is a very important matter, as it rarely happens that there is not some part of the country which escapes a drought, and to which stock in large numbers can be transferred. Another important redeeming

feature in the present position is the large number of pumping engines on the rivers and the increased knowledge of the capabilities of irrigation. There is no doubt that as soon as the pinch of drought begins to be felt, the irrigation plants in the Central and Westrn Divisions will be worked to their full capacity, and a great stimulus will be given to irrigation enterprise. It is to be regretted that the favourable seasons have had the effect of making very many of our landholders forget what a drought is like, and of lulling them into a feeling of security which the statistics of the rainfall do not warrant. In each of the three classes of country landholders—pastoralists, farmers, and fruit growers—there are men to be found who stand in the front rank in the knowledge and practice of their business, but they constitute only a small minority. Landholders as a rule are the most conservative portion of a community, and the slowest to adopt altered methods or new expedients. Still it is not likely to happen again that on rich alluvial land fronting on a permanent river, mattresses will be ripped up for the fodder which they contain, or flour used in the absence of other available food to keep horses alive, as has actually happened in times past; but it may be confidently expected that when a drought does come, many of the landholders will be badly provided with reserves of fodder to meet it. While many have neglected excellent opportunities of collecting large supplies of bush hay—that is, hay made from the natural grasses—it is not surprising that those who have pumping engines have frequently contented themselves with producing lucerne and other fodder crops in quantities very little above current requirements.

Respecting this question of irrigation for pastoral purposes, it is worth while to examine how it is dealt with in the Western States of America. In the references to American irrigation which have appeared in the press in this Colony, the fruit growing industry is so frequently referred to as to create an impression that irrigation there is confined chiefly to orchards. As a matter of fact, with the exception of California and New Mexico, all the States in which irrigation is practised have a larger area in fodder

crops than in all others combined. Not only so, but in some at least of the States, in addition to these crops, extensive areas of grass land are watered merely for pasture. In this country, though we are beyond the stage at which intelligent persons will be found to make the bald statement that irrigation will not pay, there are still many who will state that irrigation of grass land or of cereals will not pay. Such a statement is really absurd and meaningless, unless the rainfall is so abundant that further watering would not be beneficial. If by supplementing the rainfall an increased growth of grass or an increased crop of cereals resulted, clearly there would be appreciable benefit from this watering. If the value of this benefit exceeded the cost of the watering it would be clear that it did pay to have the watering. For instance, if by irrigating wheat the average yield were increased by five bushels per acre, while the cost per acre of applying the water was equivalent to the value of two bushels, there would be no question as to the watering being remunerative. It is extraordinary that so much misapprehension exists in regard to a point which seems so obvious. As a matter of fact there are places in this Colony in which irrigation of grass land is practised with great advantage, and there are others which present nearly equal facilities for it. In short where water is available or can be made available, what the landholder has to ascertain before he can come to a conclusion on the subject of irrigation is in the first place the most suitable crop to produce, in the second place the cost per acre of irrigating that crop, and in the third place the value of the increase of crop owing to watering. If this method of taking up the subject were generally adopted, there would be no doubt as to the results. I have not met with or heard of a single person in this Colony who has tried irrigation in a rational and business-like manner, who has not been thoroughly satisfied with the experiment.

When the railway system of India was much less extensive than it is now, the importance, in times of famine, of what were termed "protected areas," was recognised, and as far as possible the principle of providing for such areas was acted on. A district

was protected against famine when there was a sufficient area of irrigated land to supply food for the population within its bounds. Notwithstanding the rapid increase in the population of India, famines are becoming less frequent and less severe. This is due almost entirely to the extension of irrigation and of railway construction. The same system is wanted here, not in our case for the protection of human life, but chiefly for the protection of live stock. If the western districts were dotted over with irrigation farms, wherever water is available, and pastoralists would adopt the principle of having at least one acre of irrigation to every five hundred acres of land in its natural state, the position of the country in time of drought would be immensely improved. In land which in its natural condition cannot be depended on to feed more than one sheep to every ten acres, the importance of patches of lucerne, every acre of which will supply feed for twenty sheep is at once apparent. This is the class of irrigation which is likely to prevail throughout a large part of the colony; but on some of our rivers, and particularly on the Murrumbidgee, Murray, and Macquarie, there is scope for projects which in point of magnitude will take rank with the more important irrigation systems of the Western States of America.

I was glad to find that there is a paper by an expert in agricultural chemistry to follow this one, the subject being Irrigation from Artesian Wells. The same branch of the irrigation question was dealt with last year in a valuable paper read before this Society by Mr. Mingaye, the Chemical Analyst attached to the Department of Mines. While it would be out of place for me to attempt to deal in any way with questions which belong to experts in chemistry, it is only right that I should refer to the saline efflorescence found in many places in India, and attributed by some to irrigation. Having had the advantage of living for years in districts largely affected by the efflorescence, which is known in Upper India by the various names, "reh," "usur," "shōr," and "kullur," and having been in immediate charge of irrigation works in these districts, I am in a position to speak from actual know-

ledge of the facts. The subject is one which received much attention, both from the irrigation engineers and from the land settlement officers. For many years it has been well known in India that irrigation should not be allowed in places where the soil is much impregnated with salts or where the subsoil drainage is defective. So long ago as 1862, General Strachey of the Royal Engineers, lucidly stated the case as follows :—"The salts known as "reh" are contained in the soil. If canal percolation takes place, it may at length proceed to such an extent as to saturate the subsoil with water. The surface being at the same time exposed to sun and air, becomes heated, and continual evaporation goes on. The water lost by the surface evaporation is replaced by moisture drawn up from below by capillary action. The water coming from below contains a certain quantity of the soluble salts of the soil which it has taken up on its way : as the water evaporates at the surface the salts must be left behind, and a constant accumulation of the salt takes place on the evaporating surface. Where such efflorescence takes place at a distance from a canal, and where no free percolation takes place, it may possibly be explained by the action of an impervious stratum of clay (or kunkur) at some depth below the surface, which arrests the descent of water derived from the fall of rain (or irrigation), and accumulated from a large area into some natural depression, and held, as it were, in a basin, though of course diffused in the subsoil from which the great summer heats at length extract the whole of it with the same result as before suggested."

This theory may not meet all cases, but it is recognised that it has very wide application. Hence, when it fell to my lot to take charge of the first irrigation which was started on the Lower Ganges Canal, I had special instructions in accordance with the principles here laid down. In the early days of the large irrigation works in India, and before this question was understood, there is little doubt that in some instances the saline efflorescence was spread by injudicious irrigation ; but precautionary measures were subsequently instituted, and more recently the Indian

Government, not content with preventing the spread of the *reh*, has been conducting experiments with a view to its extirpation.

The river waters of this country, like those of India are highly suitable for purposes of irrigation, and all that is required in utilising them is to make certain that they are used only on suitable land. The waters from some of our artesian bores contain such proportions of salts that caution will be required in making use of them for irrigation. In some cases in India where the rainfall was insufficient to produce crops with any degree of certainty, while the only water available was more or less brackish, I have seen such water used to a limited extent for irrigation, the salt being in sufficient quantity to form a deposit in the small distributaries. This irrigation was adopted as the best of a choice of evils—possible privation on the one hand and probable injury to the land on the other. A similar choice of evils may have to be met sometimes in the western districts in this Colony.

In conclusion, I may point out that in regard to irrigation we have only passed the period of experiment, and have yet to deal with it on a scale commensurate with our opportunities and requirements, this fact contains much ground for consolation and encouragement in such a time of depression as we are now passing through. The immense resources of this Colony, and particularly of its soil, are altogether undeveloped. The necessity for increased production is now apparent to all, and the means to that end are therefore certain to receive more attention. As one of the most potent aids to production, irrigation will command its share of consideration ; but while our settlers are held back by the curb of antiquated and unsuitable laws, they cannot be expected to show their capabilities to advantage.